Stockholm MISTRA Institute (SMI)
on Sustainable Governance and Management of Social-Ecological Systems

Proposal to MISTRA on a new Inter-disciplinary Research Centre Initiative on Sustainable Governance and Management of Social-Ecological Systems

By
Stockholm University
Beijer Institute
Stockholm Environment Institute

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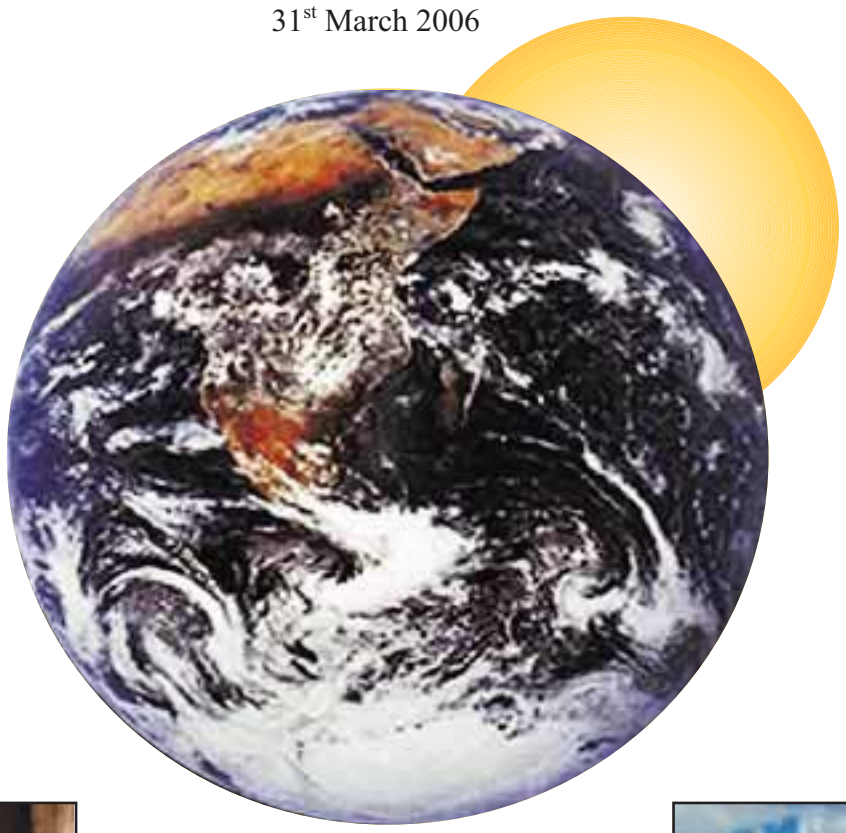

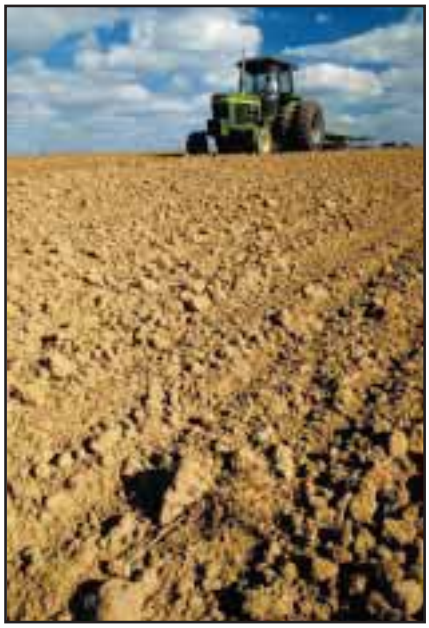

The Beijer International Institute of Ecological Economics –
The Royal Swedish Academy of Sciences

STOCKHOLMS UNIVERSITET

SEI STOCKHOLM ENVIRONMENT INSTITUTE

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1. Executive summary

Humanity is a major force in structuring ecosystem dynamics from local scales to the biosphere as a whole. Decisions in one place are increasingly influencing people and ecosystems elsewhere. Reduced temporal variability of renewable resource flows in some parts of the world has resulted in increased spatial dependence on other areas on earth. Many terrestrial and marine systems have as a result of human impacts shifted into less productive states in their capacity to generate ecosystem services to society. At the same time human societies and globally interconnected economies rely on ecosystem services and support. However, the institutional capacities to manage the earth's ecosystems are evolving more slowly than the use of the same systems (Millennium Ecosystem Assessment 2005). We are facing a cross-road where marginal change approaches in policy, governance and engineering are no longer relevant. Radically new approaches to governance and management of ecosystem dynamics from local to global scales and new principles for resource and environmental economics with far reaching implications for welfare theory are necessary. We are confronted with a new scientific endeavor to generate insights on how to face the challenge of sustainable governance and management of social-ecological systems.

The scientists at the Beijer International Institute of Ecological Economics (BI), the Centre for Transdisciplinary Environmental Research (CTM) at Stockholm University, and the Stockholm Environment Institute (SEI) who have joined forces around this proposal, have over the last two decades contributed with important advancements of interdisciplinary science. Our efforts have generated new insights into the understanding of linked social and ecological systems and the implications for governance and management. We are now prepared to take on the next challenge and we propose to establish a world leading interdisciplinary institute, the Stockholm Mistra Institute (SMI) for research on governance and management of social-ecological systems. This will require new and innovative efforts of not only linking, but truly integrating social science and humanities with natural science. It will also require that we expand the analyses into much broader both spatial and temporal scales, from local to global and from archaeology/history to future scenarios.

This is what we intend to do by developing new interdisciplinary clusters of research issues. We propose the following research agenda:

Advancing insights on complex social-ecological systems

The integrated research on complex social-ecological systems will focus on six clusters that interact, i) understanding ecosystem dynamics (e.g. resilience, regime shifts, diversity) for the generation of ecosystems services; ii) incorporating the implications of the dynamics for welfare economics, economic valuation and economic policy; iii) understanding socio-political complexity and the role of institutions, governance, and social structures in ecosystem management; iv) developing knowledge systems, participatory approaches and management practices that interpret and respond to ecosystem feedback; v) exploring actors, networks and multilevel dynamics of social-ecological systems; vi) building adaptive capacity to deal with uncertainty and change.

Cross-cutting themes

We will develop four themes that focus on how to secure ecosystem services:

1) Urban social-ecological systems and globalization,
2) Governing freshwater management for food and ecosystem services,
3) Governance and ecosystem management of coastal and marine systems,
4) Adaptive governance of dynamic landscapes.

We will also discuss the development of three-four emerging themes that focus on cross-scale interactions of social-ecological systems, with new and unforeseeable aspects to our thinking on

natural resource management: 1) international relations and social-ecological systems; 2) power, welfare states and social-ecological systems; 3) security and global change; 4) new history of crisis and resilience.

Historical observations and empirical analyses will serve as real-world laboratories of the proposed hypothesis and will generate new hypotheses. The research will be an ongoing dynamic process of inductive-deductive science that will take place on a transdisciplinary collaborative research arena. We will use quantitative and qualitative methods including various modeling approaches, empirical studies involving substantial fieldwork including experiments, participatory research methods, comparative analyses, and scenario building.

The Institute will be placed directly under the Stockholm University management. The strategic placement above the disciplinary mandates of the four faculties at SU, marks the interdisciplinary nature of the Institute and the high priority the leadership of Stockholm University gives to the new Institute. SMI will be governed by an international board, which will be responsible for the strategic direction of the Institute, the scientific and outreach achievements, the organisational structure and development, and the financial performance of the Institute. An internationally appointed Panel of Science Advisors will guide the research agenda. We suggest a shared leadership of the Institute, with an Institute Director, Dr. J. Rockström and a Science Director, Prof C. Folke, supported by a steering committee consisting of Prof. K. Eckerberg, Prof. K-G. Mäler, and Prof. S. Sörlin. SMI will be located at the Stockholm University campus, in a joint building shared by CTM, SEI and staff from the BI.

The core partners, SU, Beijer Institute and SEI, will in addition to the funds from Mistra, contribute with substantial numbers of staff and resources. Over the five year build-up phase (2007-2011) we foresee the number of staff increasing from 18 – 24 in the initial year, to 50 - 60 staff at a fully operational Institute. In total we foresee building an Institute with in the order of 100 researchers attached to it, including Institute staff and affiliated Swedish and international research staff, directly involved in research carried out by the Mistra Institute. We envision the following main forms of positions affiliated with the Institute:

Professors, Senior Scientists appointed by Stockholm University, with formal affiliation to a University faculty/department, *Research positions* at the Mistra Institute, J*oint Positions*, either contributed from the core partners or shared with Swedish and international research partners, *Visiting scientists*, including guest researchers and sabbaticals where costs are shared between the Mistra Institute and the home institution, *Young scientists*, including PhD students and Post-Doc researchers, both categories with dual affiliations to the Mistra Institute and a University faculty/department.

The flexible staffing strategy will enable adaptive solutions, while at the same time securing a strong university connection, quality control, and career consideration. The flexible structure will allow researchers to have part time or full time employment at either the Institute or the home department. We also intend to bring a substantial group of young scholars together under SMI, with the possibility of shared positions with leading research groups and institutes worldwide and secured career paths with university departments. The investment in young scientists is further emphasized by establishing the Stockholm Mistra Research School on social-ecological systems. We will mobilize leading international research groups, policy makers, practitioners and a variety of knowledge-holders in a transdisciplinary collaborative research arena.

An important part of the Institute is outreach, which we define in a broad sense, including action research approaches, as well as policy dialogues, dissemination and communication, i.e., the whole process of bridging science to society. A core feature of the new Mistra Institute is the integration of learning and participation in defining the research agenda and in the research process itself, and to continuously advice society. In our vision of building SMI to become an important actor on the global policy arena we will in addition to involvement in UN-lead processes such as the Millennium Development Process and the Commission on Sustainable Development, concentrate

our efforts on two major initiatives:

1) The Stockholm Global Forum on Sustainable Governance: a bi-annual high-level meeting where political leaders, heads of industry, representatives for civil society and top scientists will meet and discuss the wider directions of world development towards sustainable governance and management of social-ecological systems.

2) The implementation of the Millennium Ecosystem Assessment where we currently are already involved in the process of taking the results of MA into the policy and implementation domain.

The Institute will evolve through the active involvement of internationally leading scholars and a trained and inspired new generation of young scientists who are now intellectually prepared to take on the novel strategic interdisciplinary research challenges but lack a solid platform. It is such a platform that we intend to create and consolidate to substantially advance the generation of new theories and methods at the very front of interdisciplinary work for sustainability.

2. Mission statement

The scientists at the Beijer International Institute of Ecological Economics (BI), the Centre for Transdisciplinary Environmental Research (CTM) at Stockholm University, and the Stockholm Environment Institute (SEI) who have joined forces around this proposal, have over the last two decades contributed with ground breaking advancements of interdisciplinary science. Our efforts have generated new insights into the understanding of complex social and ecological system. We have learned that since cross-scale interactions and positive feedbacks cause non-linear (non-convex) dynamics and possible regime shifts in interdependent social-ecological systems, conventional models, based on dynamics approximated by linear models, are no longer useful for the purpose of navigating society towards sustainability. The same is true for conventional models of thought in the social sciences and economics.

Marginal change approaches in policy, governance and engineering are no longer relevant. Radically new approaches to governance and management of ecosystem dynamics from local to global scales and new principles for resource and environmental economics with far reaching implications for welfare theory are necessary. It is now urgent that we take the next step.

We are proposing to establish a world leading interdisciplinary institute, the Stockholm Mistra Institute (SMI) for research on governance and management of social-ecological systems, which will nurture, construct and test these new approaches on a global scale. We have the vision that in full operation, the Stockholm Mistra Institute will host approximately a hundred scientists, involved in science, scholarship, and outreach.

3. Sharing the vision

The research experience, the shared vision and the commitment to long term collaboration represented by the partners in this proposal match Mistra's strategic goal of establishing a world class centre on sustainable governance and management of ecological and social systems.

The researchers and institutes behind the proposal are well known internationally for their work on the capacity of ecosystems to generate essential services (e.g. Perrings et al. 1995, Limburg & Folke 1999, Elmqvist et al. 2003, Bellwood et al. 2004, Folke et al. 2004), the role and value of natural capital and ecosystem services in societal development and wellbeing (e.g. Jansson et al. 1994, Arrow et al. 1995, 2004, Daily et al. 2000, Mäler & Dasgupta 2003) and the management and governance of coupled and complex social and ecological systems (e.g. Costanza et al. 1993, Hanna et al. 1996, Folke et al. 2005, Hughes et al. 2005) from local to global scales (Berkes & Folke 1998, Steffen et al. 2000). They have participated in the Millennium Ecosystem Assessment by contributing to the findings on strengthened adaptive capacity for sustainable ecosystem management (e.g. Folke et al. 2005b, Kasperson et al. 2005) and by coordinating the Swedish sub-global assessments of the MA (e.g. Olsson et al. 2004, Elmqvist et al. 2004). They have a well established track record on integrated research having advanced knowledge on the links between freshwater, ecosystem functions, and agricultural development (Rockström et al. 1999, Gordon et al. 2005) and have contributed to the policy agenda on freshwater governance and management (e.g. Eckerberg 1997, Falkenmark & Folke 2003, Rockström et al. 2005). Their work on complex adaptive systems, regime shifts and resilience has received considerable attention in both science and policy (e.g. Scheffer et al. 2001, Folke et al. 2002, Kinzig et al. 2003, Norberg and Cumming 2006). The group has been at the forefront of research in vulnerability science (Bohle et al. 1994, Downing et al. 2003, Turner et al. 2003, Adger et al. 2005), particularly in terms of governance, institutional development and in the analysis of historical and cultural processes, knowledge systems, and drivers of ecosystem change (Eckerberg & Lafferty 1998, Sörlin 1998, Sörlin 2006, Sörlin & Vessuri 2006, Lambin et al. 2001). We have also substantial experience of serving as advisers and participating in policy processes from national to international levels and have worked with outreach, collaborative and participatory processes in many different settings from global to local scales and on all continents.

The three research institutes i.e. the Beijer International Institute of Ecological Economics (BI), the Centre for Transdisciplinary Environmental Research (CTM) at Stockholm University, and the Stockholm Environment Institute (SEI), and the scientists associated with this application have accumulated substantial experience of interdisciplinary scientific work crossing the boundaries of the natural sciences, the social sciences and the humanities, with collaborative networks of top scholars and research institutes on the international scene and on all continents. Research on linked social-ecological systems has developed rapidly during the last decade, progressively integrating the natural and social sciences around issues like sustainability, vulnerability and resilience. Time is now ripe to take a new major step to further develop and challenge this foundation by actively bringing in researchers from a broader set of social sciences and the humanities into addressing the implications of a complex systems approach for governance and ecosystem management.

The group has also trained and inspired a new generation of young scientists (see Appendix VII) that are now intellectually prepared to take on the novel strategic research challenges but that need a solid platform and support for interdisciplinary dialogue and research. It is such a platform that we intend to create and consolidate to speed up the generation of new theories and methods at the very front of interdisciplinary work for sustainability, if granted the Mistra Centre on sustainable governance and management of complex and dynamic social-ecological systems. A Mistra Centre in Stockholm has real potential to create an international tipping point towards deep understanding and analyses of complex social-ecological systems explicitly involving a broad spectrum of disciplines generating insights of major policy relevance.
Stockholm University, SEI, and BI (Royal Swedish Academy of Sciences) have given their full

backing to this new venture and have committed all necessary institutional support, see statement from Vice Chancellor Kåre Bremer below; Permanent Secretary, Royal Swedish Academy of Sciences Gunnar Öquist; Chairman of the Board, SEI Lars Anell (Appendix II).

The combination of an innovative shared vision, of individual, multidisciplinary strengths and committed institutions is, we believe, what is needed to fulfill the requirements for the establishment of an internationally top class and leading research centre that will help develop the scientific foundation for sustainable development, and that will make a difference in global affairs. We are all very excited about the opportunity that Mistra offers and intend to mobilize all resources and efforts necessary to fulfill the requirements for the establishment of an internationally top class and leading research centre that will help develop the scientific foundation for sustainable development and that will make a difference in global affairs.

3.1 Statement of Vice Chancellor Kåre Bremer, Stockholm University

"Stockholm University has recently decided about a long-term strategic plan. The overall vision in this plan is that the majority of the departments and institutes shall assume a nationally leading as well as an internationally recognized position. The essence of this vision is quality and the general theme is internationalization. The strategic plan involves a series of measures to increase and secure quality and to promote internationalization in our education and research.

We already have several outstanding research areas with high international status, areas represented at several departments and institutes of the university. Recently we have identified a list of such research areas where we confidently can say that Stockholm University takes a nationally leading and an internationally very well renowned position. One outstanding area is environmental research. This is performed at several of our departments from all faculties, e.g. the departments of Applied Environmental Science, Systems Ecology, Environmental Chemistry, Botany, Economics, Education, Economic History, History, Human Geography, Meteorology, Physical Geography and Quaternary Geology, Political Science, Social Anthropology, Sociology, the Stockholm Centre for Environmental Law, the Stockholm Marine Research Centre, and the Centre for Transdisciplinary Environmental Research.

Stockholm University is particularly well known for our research on sustainable governance and management of social and ecological systems. This has been achieved by a long and forceful development of systems ecology and interdisciplinary research. I would like to stress especially the competence of our Centre for Transdisciplinary Environmental Research (CTM) headed by Professor Carl Folke. Together with our two partners in this proposal, the Beijer International Institute of Ecological Economics and the Stockholm Environment Institute, the Centre recently received a large research grant for "Resilience and Sustainable Development: Integrated research on social-ecological systems" and was appointed a centre of excellence by Formas, the Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning.

Environmental research and in particular sustainable development, systems research and interdisciplinary approaches are thus particularly well represented at Stockholm University and I trust it is clear from the documentation in this proposal that it is of outstanding international quality. It is my ambition, and inherent in our strategic plan, that this research will remain a strong profile for Stockholm University for a long time into the future. The Mistra initiative thus fully corresponds with the vision and strategy of the university. I trust that our research in this field is so strong that a new Mistra institute will remain a prominent institution within the university also beyond a possible future cessation of the funding from Mistra.

Our proposal is put together by a team of scientists headed by Professor Carl Folke and the Centre for Transdisciplinary Environmental Research. Staff from all departments and centres of the university mentioned above as well as from our two external partners have been involved and/or

are planned to be part of the new institute. I believe our scientists have put together a strong and well planned research agenda. The proposal constitutes a truly interdisciplinary enterprise with participation by scientists from all our faculties. I would like to mention that the Centre for Transdisciplinary Environmental Research, which has orchestrated the proposal, is the only one of all the university centres organized directly under the university management, above the faculties. We propose a similar arrangement for the new Mistra institute, stressing its interdisciplinary character and all-faculty engagement.

We propose a physical location at Kräftriket, one of the campus areas of Stockholm University with suitable buildings immediately available. It will also be possible to offer the Stockholm Environmental Institute localities at Kräftriket, together with those of the Mistra institute. In a longer perspective it is possible to erect new buildings at the campus of Albano bordering the campus of Kräftriket. I will allocate permanently new resources covering the entire cost for the localities for the Mistra institute, estimated to up to 3 million SEK per year. In addition, the university will provide extensive co-financing though salaries and research resources for all the scientists participating from the various departments and centres mentioned above. This is specified elsewhere in this proposal. Furthermore, many of the scientists also bring substantial external research grants into the new institute, e.g. the large centre of excellence grant from Formas mentioned above.

The Director of CTM, Prof. Carl Folke, is suggested as scientific leader and the Director of SEI, Associate Prof. Johan Rockström, as the executive director of the proposed institute. A steering committee with Prof. Karl-Göran Mäler, Director of BI, Prof. Katarina Eckerberg, Deputy Director of SEI from August 2006, and Prof. Sverker Sörlin, Royal Institute of Technology, Stockholm will help lead the institute. The group represents individuals with internationally recognized expertise in the social sciences, economics, humanities and the natural sciences. I know all of them and trust that they will form an excellent and strong team. They are also well known and well respected outside the university. A Mistra institute in Stockholm will have the prerequisites, not only by its location but also by the networks of its leaders, for excellent contacts and interactions with authorities and the society in general.

Nobody can remain indifferent to the increasing problems and severe threats humanity is facing regarding the environment and the health of our home planet. I am myself a biologist and have worked for many years on plant biodiversity in many parts of the world. I have personally seen many of the problems and welcome the forceful initiative taken by Mistra. I believe Stockholm University with our documented competence and cooperation with our strong partners in the Beijer International Institute of Ecological Economics and the Stockholm Environment Institute is ideally suited to host the Mistra institute. I will do my utmost to support it."

4. The Research Agenda

The context – an emerging new understanding

Throughout history humans have shaped nature and nature has shaped the development of human society. The human dimension has expanded and intensified and become globally interconnected, through technology, capital markets and systems of governance with decisions in one place influencing people and ecosystems elsewhere. Reduced temporal variability of renewable resource flows in some parts of the world has resulted in increased spatial dependence on other areas on earth. Humanity has become a major force in structuring ecosystem dynamics from local scales to the biosphere as a whole. At the same time human societies and globally interconnected economies rely on ecosystems services and support (Millennium Ecosystem Assessment 2005). It is clear that patterns of production, consumption and wellbeing develop not only from economic and social relations within and between regions but also depend on the capacity of other regions' ecosystems to sustain them. Social conditions, health, culture, democracy, and matters of security, survival and the environment are interwoven in a grand panorama of regional and worldwide dependency.

New understanding and insights of the dynamic interplay that takes place across temporal and spatial scales are urgently required to guide governance and management practices in order to secure ecosystem services for a prosperous societal development. Many terrestrial and marine systems have already shifted into less productive states in their capacity to generate ecosystem services to society (Scheffer et al. 2001, Folke et al. 2004), a historical pattern that has escalated during the last century (Jackson et al. 2001), and flows of resources are increasingly characterized by uncertainty and surprise (Kinzig et al. 2003).

To what extent are human societies adapting their capacity for learning and foresight to deal with this new and challenging situation? We strongly agree with the Millennium Ecosystem Assessment and Mistra that the institutional capacities to manage the earth's ecosystems are evolving more slowly than humanity's [over]use of the same systems.

4.1 The research challenge

Our research agenda states that because of cross-scale interactions, positive feedbacks causing non-linear (non-convex) dynamics and possible regime shifts in interdependent social-ecological systems, new approaches to governance will be necessary for guiding management and policy of ecosystem services towards sustainability. Conventional models, based on linear (or convex) dynamics, are no longer useful for the purpose of navigating society towards sustainability. The same is true for conventional models of thought in the social sciences and economics.

Three fundamental hypotheses form this research agenda:

i) society and nature represent *interdependent social-ecological systems*
ii) social-ecological systems are *complex adaptive systems* and
iii) *cross scale and dynamic interactions* represent new challenges for governance and management in relation to interdependent social-ecological systems and ecosystem services.

4.1.1 Interdependent social-ecological systems

In our view, there are neither natural or pristine systems without people nor social systems without nature. Social and ecological systems are not just linked but truly interconnected and co-evolving across spatial and temporal scales (Norgaard 1994). We refer to them as social-ecological systems (Berkes & Folke 1998). We will here use the concept social-ecological since it emphasizes the humans-in-the-environment perspective; that earth's ecosystems, from local areas to the biosphere as a whole, provide the biophysical foundation and ecosystems services for social and economic development. But also that the ecosystems we observe today have been shaped by human decision

making throughout history and are intertwined with human actions that directly or indirectly alter their capacity to sustain societal development.

It is difficult and even impossible to truly understand ecosystem dynamics and their ability to generate services without accounting for the human dimension. Focusing on the ecological side only, as a basis for decision making for sustainability, simplifies reality so much that the result is distortions and leads to incomplete and narrow conclusions. Doing the natural science first with the social dimension added on later in the processes misses essential feedbacks. The same is true for social sustainability. Despite a vast literature on the social dimension of resource and environmental management, studies have often focused on investigating processes within the social domain only, treating the ecosystem largely as a given, an external "black box", assuming that if the social system performs adaptively or is well organized institutionally it will also manage ecosystems in a sustainable fashion. A human society may show great ability to cope with change and adapt if analyzed only through the social dimension lens. But such an adaptation may be at the expense of changes in the capacity of ecosystems to sustain the adaptation, and may generate traps and breakpoints in social-ecological systems.

Our focus is on interdependent social-ecological systems (Berkes et al. 2003) and the efforts to truly understand such systems are still in an exploratory stage and there is great opportunity for creative approaches and perspectives.

4.1.2. Complex adaptive systems

Evidence points to a situation where periods of abrupt change due to climatic and global change are likely to increase in frequency and magnitude (Steffen et al. 2004). This poses new fundamental challenges for science, management, policy and governance. At the same time, human actions have often pushed ecological systems into less productive or otherwise less desirable states with negative consequences for human livelihood and security. The existence of such 'regime shifts' is an area of intense research (Scheffer et al. 2001) with examples from forests, lakes, wetlands, coastal areas, fisheries, coral reefs, (Folke et al. 2004), grazing lands (Scholes & Walker 1993), agriculture (Rockström 2003) and marine systems (Troell et al. 2005, Grebmeier et al. 2006), including the Baltic Sea (Österblom et al. in review). In some cases, these shifts may be irreversible or too costly to reverse.

Contemporary resource and environmental management and associated policies, including economic instruments and incentives, have to a large extent been based on steady-state views and assumptions. The new reality profoundly contests models and policies that are based on assumptions of linear dynamics, with a focus on optimal solution in the vicinity of a single equilibrium (Dasgupta & Mäler 2003). Recent research has revealed that applications of such theory and world views tend to develop governance systems that invest in controlling a few selected ecosystem processes, causing loss of key ecological support functions, in the urge to produce particular resources to fulfill economic or social goals (Holling & Meffe 1996). These practices reduce the capacity to deal with change and continue to develop and may result in vulnerable systems subject to regime shifts, which may lead to poverty traps.

To address these challenges, we advocate a complex adaptive systems approach and argue that social-ecological systems are complex adaptive systems characterized by historical (path) dependency, non-linear (non-convex) dynamics, regime shifts, multiple basins of attraction and limited predictability. Theories of complex systems portray systems not as deterministic, predictable and mechanistic, but as process dependent organic and self-organizing with feedbacks between multiple scales (e.g. Holland 1995, Arthur 1999, Levin 1999). Complexity makes it hard to forecast the future. Not only are forecasts uncertain, the usual statistical approaches will likely underestimate the uncertainties since key drivers like climate and technological change are unpredictable and may change in non-linear fashions (Kinzig et al. 2003, Peterson et al. 2003).

The complex adaptive systems approach shifts the perspective on governance from trying to control change in resource and ecosystems assumed to be stable, to enhancing the capacity of social-

ecological systems to learn to live with and shape change and even find ways to transform into more desirable directions. It is in this context that the Stockholm group, in collaboration with many institutes and scholars, works internationally with the ***resilience*** perspective. Resilience is the capacity to absorb change, reorganize and continue to develop. The concept of resilience was invented to address the paradox of how change and persistence work together (Holling 1973). Resilience research addresses how systems assimilate disturbance, innovate, and change, while simultaneously maintaining characteristic structures and processes (Folke 2006).

In a vulnerable system even small disturbances may cause dramatic social consequences. It is argued that managing for resilience enhances the likelihood of sustaining desirable pathways for societal development in changing environments where the future is unpredictable and surprise is likely (Adger et al. 2005). Increased vulnerability, as a consequence of loss of resilience, places a region on a trajectory of greater risk to the panoply of stresses and shocks that occur over time (Kasperson et al. 1995, Schröter et al. 2005).

4.1.3 Cross-scale and dynamic interactions

Scale issues are central in dealing with complex adaptive systems. Social-ecological systems are linked across temporal and spatial scales and levels of organization and decisions in one place affect people elsewhere. Local groups and communities are subject to decision from regional levels and connected to global markets and vice versa. A social-ecological system can avoid vulnerability at one time scale through the technology it has adopted. Similarly, resilience at one spatial extent can be subsidized from a broader scale, a common pattern in human cultural evolution (Redman 1999, van der Leeuw 2000) and exacerbated by technology, capital markets and financial transfers that mask environmental feedback (Berkes & Folke 1998, Gunderson & Holling 2002). New insights are emerging on cross-scale interactions in social-ecological systems (Gunderson et al. 1995, Young 2002, Cash 2006) including dynamics of social and economic drivers of land use change (Lambin et al. 2003) and on governance systems that allow for learning and responding to environmental feedback and change (Dietz et al. 2003).

The interplay between individuals (e.g. leadership, teams, actor groups), the emergence of nested organizational structures, institutional dynamics, and power relations tied together in dynamic social networks are examples of features that seem critical in governance that allows for ecosystem management and for responding to environmental feedback across scales (Folke et al. 2005).

The translation of scale concepts to social systems is not simple (Gibson et al. 2000). Institutions can be scaled by the number of people they affect, and the time horizon of institutional change. Some features of human demography, governance and economics can be mapped to dimensions that resemble ecological scaling. On the other hand, human capacities for abstraction and reflexivity, forward-looking action, and technology development are strikingly different from non-human systems (Westley et al. 2002). These capacities enable human systems to transcend constraints of ecological scale. Thus, patterns of change across scales may not provide satisfactory explanations of resilience in social-ecological systems.

It may be necessary to address cross-*system* interactions, retaining the many dimensions that differentiate subsystems, instead of compressing the dynamics to one or two scaling dimensions. Thus cross-scale, or cross-system, interactions are a critical research frontier for social-ecological systems. How do multiple subsystems interact to create, or erode, resilience? What kinds of social-ecological configurations lead to sustainable versus unsustainable societies? These are important questions that are just beginning to be addressed.

One hypothesis is that societies tend to lose resilience as they become more extended in space or more complex in structure. The same environmental stress that could be easily handled in earlier, less complex stages of a society's development can thus become sufficient to cause collapse if it occurs when society has become vulnerable (Tainter 1988). The issues of globalization as they

relate to consumption patterns, energy and technology and how it shapes the capacity of social-ecological systems to sustain ecosystem services warrants further investigation.

Still, there persists a wide gap between this research and the large, mainstream of work in the social and cultural disciplines. This is quite understandable; research traditions on economics, politics, and security have grown within disciplines which have focused on human agency and social institutions. Although there are those that have worked on linking human agency to nature, there is potential for a more systematic integration of research on society, nature and human agency (Rayner & Malone 1998).

The Stockholm group has worked for more than two decades on "big interdisciplinarity" bridging the social and natural science approaches to social-ecological systems. Still, we have only scratched the surface of an immense research challenge that promises to provide a much richer understanding of not just human-environment interactions but of how the world we live in actually works and the implications it has for current policies and governance. The research holds the prospect of major changes of our world view. Yet the interdisciplinary approach of the proposed Institute will not make specialised and discipline-based studies superfluous, quite the contrary. What we are proposing is in a sense itself a specialisation, a hybrid of multiple specialisations into new broad approaches, with a systems view as a main feature and with implications for management and governance that are wide ranging.

There are few research institutes and scholars that have started to address complex adaptive systems approach to understand interdependent social-ecological systems and their cross scale and dynamic interactions in a robust fashion, merging the natural and social sciences and the humanities in a profound sense. In the proposed Mistra Institute we will have the capacity to profoundly address cross-scale social-ecological dynamics, from local communities to global change issues, through the diverse set of expertise within the Stockholm Group and of our international collaborators (see section the research platform). *Resilience, vulnerability and adaptability* are central themes of our research efforts, cutting across economics, humanities and the social and natural sciences. We will also draw on and develop insights from the rise and fall of complex societies, to the history of human use and misuse of ecosystems to the present situation and also to the future through e.g. scenario work.

We regard as the mission of our research – not to find the ultimate solution to an endlessly complex problem, but to work with social actors and interests in different parts of the world towards the understanding of complex processes, so as to make real progress possible. Even this more modest task is truly daunting enough to keep even a large center of research going for a long time. It is our understanding that these issues will not leave us soon, they will be there as a major challenge for a mankind that has, in all probability, a long period of continued and even increased economic growth ahead.

It would be pretentious to suggest that we know the content or direction of the future world view to emerge from the research efforts that are now being conducted around the world. What we do say, however, is that we regard our own work in the light of the potential to influence it in a significant way. Indeed, we see this as a responsibility.

4.2 The research focus

Our work over the past decades, and in particular the iteration between theory, comparative work and case studies, has provided a new direction, under continuous development, for governance and management of social-ecological systems in the face of uncertainty and change (Folke et al. 2002). It differs from current approaches that tend to take the self-repair capacity of ecosystems for granted and stresses that it will not be sufficient to reduce pressures on ecosystem (e.g. pollution, fishing pressure) to sustain and develop the environmental resources base for societal development. The variables and processes that structure ecosystem dynamics and the sources of social and

ecological resilience, vulnerability and adaptability have to be understood and actively managed to deal with the consequences of the interplay of gradual and abrupt change. It implies expanding analysis into broader spatial and temporal scales. A major challenge in this context is to build knowledge, incentives, and learning capabilities into institutions and organizations for governance of local, regional and global ecosystems and to incorporate actors in new and imaginative roles. We will expand our efforts on developing theory, operational concepts, measures, and policy-relevant tools and new insights for social-ecological systems. Clusters of research issues that we intend to address include:

- What are the processes and functions that generate ecosystem services and how can they be managed?
- To what extent is there a need to revise current approaches to economic policy, valuation, and indicators of progress and wealth in the light of non-linear (non-convex) dynamics, cross-scale interactions, changes in resilience, and pervasive uncertainty?
- How do dramatic events in social systems, such as drastic changes on global markets or shifts in political systems interact with and change ecosystems and ecosystem services?
- What are the basic institutional foundations in social-ecological systems that strengthen or weaken adaptive capacity and how do institutional interactions across temporal and spatial scales affect adaptive capacity?
- How can governance systems that support sustainable management of ecosystem services be shaped and stimulated to emerge across spatial and temporal scales in order to cope with uncertainty, surprise and vulnerability in an increasingly globalized society? What are the lessons from past experience and history and what are the prospects for the future?

Historical observations and empirical analyses serve as real-world laboratories of the proposed hypothesis and will generate new hypotheses. Based on those findings, theoretical notions are developed, tested, and integrated and will generate new conceptual models and theories that will feed back into the research issues. The research is an ongoing dynamic process of inductive-deductive science that will take place on a transdisciplinary collaborative research arena with active involvement of scholars from the natural and social sciences and the humanities. We will use quantitative and qualitative methods including various modeling approaches, empirical studies involving substantial fieldwork including experiments, participatory research methods, comparative analyses, and scenario building. We are aiming at truly transdisciplinary syntheses.

The research of the SMI will initially be structured into two major parts:
- Advancing insights on complex social-ecological systems
- Cross-cutting themes for learning and application

Advancing insights on complex social-ecological systems
The integrated research on complex social-ecological systems will focus on six clusters that interact:
- understanding ecosystem dynamics (e.g. resilience, regime shifts, diversity) for the generation of ecosystems services;
- incorporating the implications of the dynamics for welfare economics, economic valuation and economic policy;
- understanding socio-political complexity and the role of institutions, governance, and social structures in ecosystem management;
- developing knowledge systems, participatory approaches and management practices that interpret and respond to ecosystem feedback and continuously learn;
- exploring actors, networks and multilevel dynamics of social-ecological systems;
- building adaptive capacity to deal with uncertainty and change (e.g. shifts in political systems, extreme events, socioeconomic driving forces).

Cross-cutting themes for learning and application
There will be cross-cutting themes that draw on major international and interdisciplinary collaborative efforts of the research institutes for improved governance and management of

social-ecological systems and ecosystem services. Learning, application and policy will draw on and feed into the above integrated research clusters;

There will be four themes that focus on how to secure ecosystem services

- Urban social-ecological systems and globalization
- Governing freshwater management for food and ecosystem services
- Governance and ecosystem management of coastal and marine systems
- Adaptive governance of dynamic landscapes

These themes will "kick-start" through the platforms of collaboration among our research groups and take on the challenge of truly integrating natural science with social science and the humanities for new innovative insights, applications and policy developments. New and innovative solutions for governance and management are envisioned to emerge. International research collaboration will be substantial. These research themes are presented in the Research Agenda below.

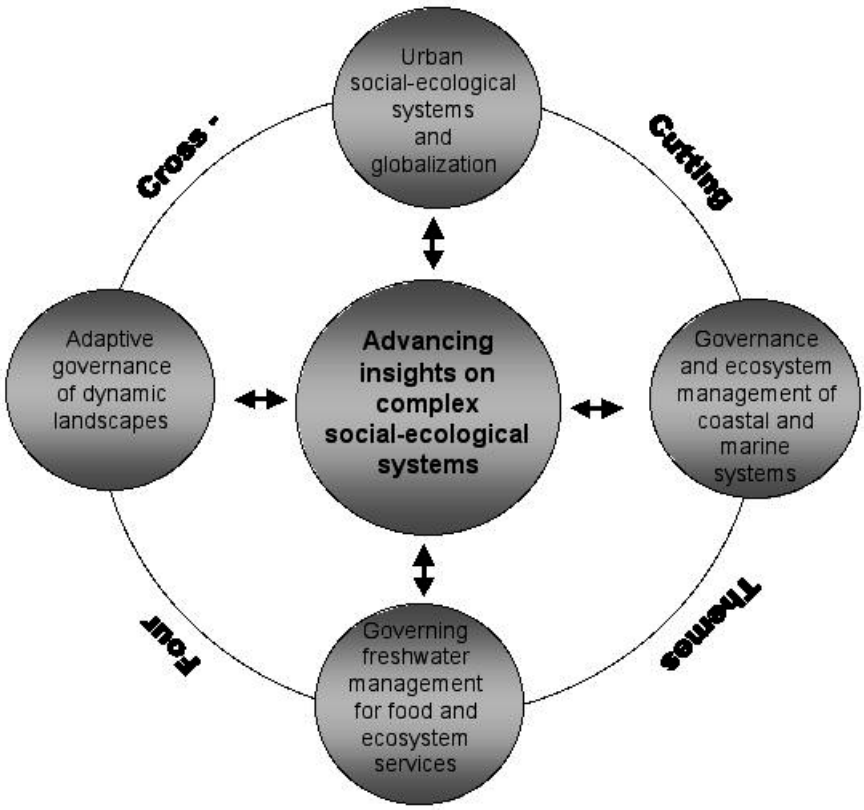


Figure 4.1. The research focus – Advancing insights on complex social-ecological systems and Cross-cutting themes for learning and application

In our vision of the Institute we are further exploring and planning three to four central emerging research issues. We would already from the start like to use them to create a strong bridge with new and unforeseeable aspects to the thinking on ecosystem services management. It is our ambition to use the emergent issues to provide new inputs to the existing research groups and to spark off new patterns of cooperation. These research issues are presented in the Research Agenda below.

Adding novel, albeit high-risk, lines of research to the Institute will also very likely lead to the emergence of entirely new research areas which we can not foresee at this time. Our experience is that research areas mature gradually and we will carefully select our additional researchers and manage their contributions so as to strengthen the overall performance of the Institute.

During the build-up phase we will explore the following emergent research issues on complex systems and cross-scale interactions:

- international relations and social-ecological systems;
- power, welfare states and social-ecological systems;
- security and global change;
- new histories of crisis and resilience.

They promise to contribute insights that are crucial to our understanding of social-ecological systems in at least five dimensions. First, international relations – diplomacy, foreign policy, environmental negotiations – are means of carrying forward the insights from social-ecological systems research into the international arena. As research on SES (social-ecological systems) matures and useful applications are developing this line of work becomes increasingly important.

Second, SES research will not get very far if it is not compatible with the operational principles of democratic welfare societies. The social-ecological systems that are needed in order to achieve impacts on modern economies and societies must take real world citizens and democratic systems into account.

Third, as SES research gradually takes on larger and more complex systems on national and regional scales issues of globalization and security become more pressing. Prevention and management of natural as well as human-made disasters must come on our research agenda and synergies between SES and global security and global change issues must be put to use and become visible. Fourth, there is a growing need to rethink the general social and historical context within which we consider human-nature relationships. In a certain sense all researchers at the Institute contribute to this process, but the social sciences and the humanities in particular can take on the mission of rearranging our systems of orientation. To provide context and narrative is to make it possible for people that ultimately make the decisions to grasp the Big Picture of social-ecological systems and the implications for sustainable management of ecosystem services.

Fifth, as is evident from the preceding four points, these additional themes will address social applications on larger scales in space and time to improve the realization of social-ecological systems research into applicable governance models. Needless to say, since these are emergent issues they should be regarded as the fertile 'test beds' of new research ideas and our vision is that they will feed into the four themes on governance and management of ecosystem services in a very productive way.

4.3 Advancing insights on complex social-ecological systems

4.3.1. Ecosystem dynamics and the generation of ecosystems services

In ecology, a focus on ecological life-support systems and ecosystem services emerged a few decades ago (e.g. Ehrlich & Mooney 1983, Odum 1989, Folke et al. 1991, de Groot 1992) summarized in "Nature's services" (Daily 1997). At the same time, the interdisciplinary field of ecological economics developed the concept natural capital (Costanza & Daly 1992, Jansson et al. 1994, Dasgupta et al. 1994), which includes non-renewable resources, renewable resources and ecosystem services (the latter two generated by ecosystems), to make social scientists and in particular economists aware of the significance of ecosystems as providing the biophysical foundation for societal development (Perrings et al. 1992, Arrow et al. 1995).

Identifying and quantifying ecosystem services
Ecosystem services were adopted as a central concept by the Millennium Ecosystem Assessment to include provisioning services (e.g. food, fiber and fresh water), regulating services (e.g. water and air purification, climate regulation and soil development), cultural services (e.g. educational, recreational or spiritual values of ecosystems), and supporting services (e.g. primary production and nutrient cycling). Numerous research efforts are taken place to quantify ecosystem services and address the capacity of ecosystems to sustain them (e.g Limburg & Folke 1999, Kremen 2005). To manage ecosystem services, one must know what they are, as well as their location, abundance, rates of renewal, dynamics and resilience. Uncertainty is inescapable in assessments of ecosystem services. Ecosystem dynamics are complex and multicausal, and causes may be remote in space and time from the events that we wish to anticipate. Considerable work is needed on the identification of uncertainties and ambiguities in ecosystem services and on quantifying uncertainties where possible (Carpenter & Folke 2006).

The MA made an important contribution by identifying ecosystem services that regulate climate, floods, diseases, water and air quality, and so forth. However, the connections of these regulating ecosystem services to ecosystem dynamics and resilience are not well understood. Apparently the reliability of ecosystem services depends on resilience, and resilience is a reflection of features of ecosystems shaped by human actions in complex ways. Elucidating these linkages is a fundamentally important research challenge.

The role of biological diversity in ecosystem functioning, processes and resilience
Recent research has illustrated that biological diversity plays a significant part in ecosystem dynamics and resilience (Hooper et al. 2005). Functional groups of species maintain ecosystem performance and the services that they generate. Functional groups refers to groups of organisms that e.g. pollinate, graze, predate, fix nitrogen, spread seeds, decompose, generate soils, modify water flows, open up patches for reorganization and contribute to the colonization of such patches. Loss of a major functional group causes drastic alterations in ecosystem functioning (Chapin et al. 1997, Jackson et al. 2001). Response diversity, i.e. different responses to environmental change among species that contribute to the same ecosystem function, seems to be critical in ecosystem resilience (Elmqvist et al. 2003). Such species replace each other over time, ensuring maintenance of ecosystem function over a range of environmental conditions and thereby the flow of ecosystem services. Regional losses of such species increase the risk of large-scale catastrophic ecosystem shifts because spatial sources for ecosystem reorganization after disturbance are lost (Bellwood et al. 2004). The role of such functional diversity in sustaining ecosystem services is an area under intense investigation and of fundamental importance for sustainable management of ecosystem services. It shifts perspective from conservation of species to managing their roles in ecosystem dynamics in order to secure and develop ecosystem services for social and economic development (Perrings et al. 1992, Folke et al. 1996, 2004).

Resilience and regime shifts
Resilience is the capacity of a system to regenerate and sustain specified conditions or processes and continue to develop in spite of exogenous disturbances or changes in driving forces (Holling 1973). Resilience is related to the distance of a system from a critical threshold, and therefore it changes over time and can potentially be managed (Carpenter et al. 2001). Ecosystems with reduced resilience may still maintain function and generate services, i.e. may seem to be in good shape, but when subject to a sudden event (like a flood or heavy rainfall), they may shift into another less desirable state. Passing a threshold into other states is referred to as a regime shift (Scheffer et al. 2001). Regime shifts can produce large (and often unexpected) changes in ecosystem services. Examples at local and regional levels include eutrophication of lakes, degradation of rangelands, shifts in fish stocks, breakdown of coral reefs, and persistent drought. Examples at larger scales are shifts in water currents, dry and wet period of continents or climate change. Indicators that focus narrowly on the flow of the ecosystem service itself (e.g. crop or livestock yields) miss impending regime shifts (e.g. salinization of cropland or collapse of livestock due to replacement of grasses by woody vegetation in rangeland).

Regime shifts of ecosystems are to a large extent driven by human actions. A combination of top-down impacts, such as fishing down foodwebs and losing response diversity and functional groups of species, and bottom-up impacts, like accumulation of nutrients, soil erosion or redirection of water flows, as well as altered disturbance regimes, such as suppression of fire and increased frequency and intensity of storms, have shifted several ecosystems into less desired states with diminished capacities to generate ecosystem services (Folke et al. 2004), a phenomena that takes place from rangelands to coral reefs and from catchments to continents. Recent work suggest that complex systems "stutter" or exhibit increased variance at multiple scales in advance of a regime shift (Carpenter & Brock, 2005). Such increases in variance help characterize regime shifts, and may even allow early warning indicators of some regime shifts. Furthermore, multiple thresholds and regime shifts at different scales and in different and interacting ecological, economic and social domains are proposed to exist within regional social-ecological systems (Walker et al. 2006).

The theoretical basis for regime shifts in ecosystems has been described in e.g. Scheffer et al. (2001). The theoretical basis and implications for economic systems have been described in Dasgupta and Mäler (2004). Regime shifts are discussed also in social systems, for example in the development of scientific knowledge systems (Sörlin & Vessuri 2006), and such shifts interrelate in complex ways with traditional knowledge systems and with shifting policies and management of natural resources (Turnbull 2000, Law 2004). Regime shifts have been described for legal systems, institutions, societies (Esping-Andersen 1996, Redman 1999). There are scholars that have interpreted social dynamics in terms of regime shifts, for example, in relation to vulnerability and collapse of ancient societies (Janssen et al. 2003, Diamond 2005), to opinion shifts in relation to leadership, social capital and learning for how to deal with complex adaptive systems (Scheffer et al. 2003) or the emergence of tipping points and multistable behavior of social systems (Brock 2006).

The resilience perspective with multiple basins of attraction and regime shifts has influenced fields like anthropology where e.g. Vayda and McCay (1975) challenged Rappaport's (1967) concept of culture as an equilibrium-based system, in ecological economics in relation to biological diversity (Perrings et al. 1992), non-linear (non-convex) dynamics (Common & Perrings 1992, Dasgupta & Mäler 2004) and the modeling of complex systems of humans and nature (Costanza et al. 1993), in environmental psychology (Lamson 1986), cultural theory (Thompson et al. 1990), human geography (Zimmerer 1994), the management literature (King 1995), property rights and common property research (e.g. Hanna et al. 1996) and other social sciences (reviewed in e.g. Scoones 1999, Abel & Stepp 2003, Davidson-Hunt & Berkes 2003).

Spatial and temporal interactions

With the rise of landscape ecology (e.g. Turner 1989) and insights on cross-scale dynamics in ecological systems (e.g. Holling 1992, Levin 1992) along with an increasing availability of long-term records on ecosystem change and long-term degradation (e.g. Zimov et al. 1995, Jackson et al. 2001, Steffen et al. 2004, Kirch 2005), the window has now opened for a deeper understanding of the broader spatial and temporal context and behavior of multiple basins of attraction of human shaped ecosystems and their capacity to generate ecosystem services subject to social drivers.

A constraint of many analyses is the relatively short temporal scale of decadal to half a century of many observations. A decadal time scale focus will miss larger temporal and spatial scales, so called creeping changes, and the acceleration of system dynamics. There are many examples where human actions have altered slowly changing ecological variables, such as soils or biodiversity, with social consequences that did not appear until long after the ecosystems were first affected (e.g. Allison & Hobbs 2003). Extensive land clearing during the last two hundred years has removed native woody vegetation for agricultural crops and grasses that transpire much less water. Thereby, more water has been infiltrating the soils and as a consequence the ground water table has risen and causes problems with salinity both in rivers and in the soils severely reducing the capacity for growth of agricultural produce (Gordon et al. 2003).

Landscape ecology has highlighted the importance of spatial configuration for species persistence and management in fragmented landscapes and the role of surrounding habitats for ecological processes. Extensive work in biogeography has shown that variation in immigration and dispersal is important for species composition. Furthermore, the spatial scale of dispersal of functional groups of species is crucial for understanding the dynamics of ecosystems and the generation of ecosystem services (Nyström & Folke 2001). Conventionally, ecologists have assumed that damaged ecosystems will recover to equilibrium conditions given sufficient time. However, we have now learned that even where local populations are highly interconnected, if too many patches of habitats degrade, the remaining healthy ones can catastrophically collapse, once a critical threshold is passed (Hughes et al. 2005). From a complex systems perspective, the small-scale degradation of each patch represents a regime shift and the dynamics of individual patches can propagate to much larger scales, potentially leading to a regime shift of the entire system. Importantly, because system-wide collapse is an emergent property of small-scale dynamics, even the most rigorous management of remnant areas could be too little, too late.

The important lesson for ecosystem management is that multi-scale dynamics requires multi-scale management, not just small-scale meddling. The challenge for governance and management of complex cross-scale dynamics, that may extend national borders, is substantial. We will perform studies in terrestrial and marine ecosystems that aim at

- Understanding resilience through a focus on (i) spatial dynamics (ii) cross-scale effects, timelags and feedbacks, and
- analyzing important functional groups of organisms that contribute to ecosystem resilience.

4.3.2. The new welfare economics, economic valuation and economic policy

Environmental and resource economics has roughly been developing from the beginning of 1950's. It has played an important role in many policy contexts and many countries are now applying economic instruments to improve the environment. Although such instruments in the form of taxes were conceptually introduced already in the 1920's (Pigou), it is only during the last twenty years that they have been introduced on a large scale. The development of social cost benefit analysis has now reached a status that it is legally required in some countries, e.g. United States of America. This has required economists to find ways of valuing environmental resources that are not priced on markets.

The development has resulted in a number of techniques to estimate the relevant "accounting" prices. Furthermore, resource economists have, since Gordon's pioneering work in the 1950's, found ways of determining sustainable yield and economic optimal harvests of living species (fish, forests etc) as well as for non renewable resources (oil, ores etc.). This substantial progress has only to limited extent taken complex systems dynamics into account. We have learned from research at the Beijer Institute that the focus now must change. In this proposal for the Stockholm Mistra Institute, we want to address following problems that exist in current economic approaches:

1) Most of the research till now is based on linearity (or rather convexity) which excludes existence of bifurcations in dynamic systems, such as regime shifts.
2) Very little has been done to incorporate ecosystem services in general in the analysis
3) Very little has been done on the spatial aspects of resource and ecosystem dynamics
4) Current macroeconomic indicators, such as GNP or NNP or HDI (Human Development Index) are useless for monitoring the sustainability of an economy. We will develop indicators that better capture interdependent social-ecological systems.

We intend to further develop research on these four issues, because their policy implications are far reaching. Economic instruments applied in environmental policy work best in stable environments. The existence of positive feedback leading to non-convex dynamics and regime shifts makes it impossible to use standard economic instruments in an efficient way (Mäler et al. 2004). It should be acknowledged at the outset that this research agenda has been central to the activities within the Beijer Institute for more than fifteen years (www.beijer.kva.se). The collaboration

particularly between ecologists and economist has revealed the significance of ecosystem services, the essential role that biodiversity plays, across temporal and spatial scales, in ecosystem processes and functioning and in particular the importance of the dynamics of ecosystems for economic analysis and policy and for societal progress.

Non-convex dynamics

Around 1995, The Beijer Institute together with University of Florida, Gainsville, initiated with funding from the MacArthur Foundation, the Resilience Network. The aim of the network was to study the dynamics of ecosystems and its implications for policy and governance. We refer to this dynamics as non convex dynamics. The basic mechanism behind non convex dynamics is the existence of positive feedbacks to perturbations of the system. If a perturbation moves the system in one direction, a negative feedback moves it in the opposite direction and stabilizes the system. Positive feedbacks will be destabilizing, that is they will strengthen the original perturbation. In Appendix IX we provide illustrations of the implications of non-convexity in relation to fisheries and eutrophication of lakes (Carpenter 2003, Scheffer 1998).

There are now ample observations on "non convexity" in resource and ecosystem dynamics. The recent report from the IGBP (Steffen et al. 2003) illustrates well the conclusion that non convex dynamics may be the generic situation in biophysical systems in general and not only in local ecosystems. In climate sciences quite many positive feedbacks have been identified. The most obvious one is the melting of the permafrost in the arctic areas which will release methane and by that heating the atmosphere further. Another example is given by the possible collapse of the North Atlantic halocline.

The analyses of complex dynamics (see Appendix IX) make clear that our intuition, which has been formed by the linear (convex) dynamics we have learnt from textbooks and our own superficial experiences, is of limited use in predicting the behavior of complex dynamic systems. It will not help us in finding guidance for effective management of systems with non-convex dynamics. Optimal management will often, because of the complex dynamics, be extremely difficult if not impossible to implement (Brock et al. 2002, Crépin 2004). In the government's long run planning the risk of crossing a threshold must be accounted for. So far, there exist neither attempts nor appropriate tools to capture regime shifts. Aspects of non-convexity have yet to be incorporated into models that inform resource and environmental management and make managing for resilience operational.

There is an urgent need to develop the analysis of proper policy instruments to cope with regime shifts and multistate environments. We intend to further contribute to that development. Researchers involved with the Stockholm group are at the research front in progressing the economic analysis of such systems (Dasgupta & Mäler 2003). The research will develop a conceptual management framework that accounts for the risk of loss of resilience. Whenever resilience and regime shifts are in focus it seems necessary to include risk assessment, risk valuation and uncertainty, which is seldom done.

Valuation of ecosystem services

Valuation of ecosystem services involves the value to mankind from a change in the underlying system. But, a change in the underlying system may involve a regime shift with may lead to a completely different supply of ecosystem services. Thus, valuation must include an investigation of the dynamics of the system to ascertain the risk for a regime shift. We have not seen this being done in the literature on valuation of ecosystem services. Most approaches to valuation attempt to capture the value of marginal change under assumptions of stability near a local equilibrium (Daily et al. 2000). They seldom take into account the inherent complexities and resulting uncertainties associated with ecosystem management and natural capital assets in general and ignore the broad-tailed and slowly-changing probability distributions of critical ecosystem thresholds (Brock et al. 2002). This has major implication for policy, particularly since economic pricing and valuation is stressed in policies from international organizations to local decision-makers.

Accounting prices for ecosystems
In any attempt to broaden the present indicators of economic performances, it is necessary to include the value of ecosystems. However, there are no market prices for ecosystems and we have to construct such prices from basic principles. By definition, an accounting price of a stock is equal to the present value of the perturbations of future "utility" levels following from a small perturbation of the present stock (Arrow et al. 2003). Resilience could be regarded as stock and should therefore have an accounting price. The question is how to define the accounting price for resilience. This question has been raised in relation to salinization problems in southeastern Australia and the Beijer Institute has been able to develop a conceptual framework for dealing with this problem (Mäler et al. 2005).

Spatial dynamics
Spatial aspects are seldom incorporated in current resource management models. The program will focus on investigating the ecological and economic implications of spatial dynamics and develop tools to include it in resource management models. Some examples of important problems that involve spatial/dynamic processes include: epidemics, invasive species spread, animal disease transmission, forest pest invasion, and management of marine and terrestrial reorganization of ecosystems governed by dispersal. A common thread among these examples is that each depends upon biophysical mechanisms that can be modeled as dispersal processes. From a policy perspective, these examples pose important questions about where, when and how much regulatory effort ought to be utilized to mitigate the problem.

The inclusion of studies of spatial-dynamic processes that link ecological and economic systems is a timely because there is a wealth of new data being accumulated with remote sensing and other global monitoring technology that scientists are only recently beginning to assess. These accumulating data are posing new questions in the sciences about spatial processes and they are stimulating revision of paradigms that previously lacked spatial character. Similar paradigm revisions are needed in economics because, while economists have developed a rich body of concepts to understand the intertemporal dimensions of resource and environmental problems (e.g. discounting, intergenerational issues), the focus on space and dispersal processes is a relatively new and undeveloped area of inquiry.

A multidisciplinary focus on spatial/dynamic processes has promise to provide generalizations of concepts economists have developed to understand the dynamic aspects of resource and environmental problems, and new insights into the kinds of institutions that are needed to cope with important spatial-dynamic problems. A focus on spatial-dynamic processes is explicitly in focus in the four themes for learning and application on urban systems, marine systems, food and freshwater and dynamic landscapes.

Wealth and sustainable development
Sustainable development is development during which we, by saving as much resource as we inherited, endow the next generation, in order to enable them to have a life as good or better as we have. Thus an index of sustainability should be an index on how the present generation endow the future generations with resources. This has been developed into a formal theory by Arrow, Dasgupta & Mäler (2003) and implementations of the theory have been started in many parts of the world: Australia (B. Walker), Tanzania, Ethiopia, Namibia (Lange), Botswana (Lange), South Africa (RANESA), Venezuela (Aniyar), Stockholm's country (Mäler). Furthermore, The World Bank has compiled a set of statistics on genuine savings which includes changes in human capital (approximated by expenses on education), depletion of subsoil resources, deforestation and emissions of CO_2 for all of the member states of the Bank. Based on that, the Beijer Institute has made a first attempt to measure the sustainability of some of the member countries (Arrow et al. 2004). As a general finding, wealth per capita (the sustainability index) increases much slower than GDP per capita. For some countries with positive GDP per capita growth, wealth per capita is in fact decreasing. For all sub Saharan countries in Africa wealth per capita is falling. The exception is Botswana, where wealth per capita is increasing.

However, these are very preliminary results and are very probably overly optimistic. As we have not been able to include ecosystems and their resilience in our capital concept and as we know (for example from the Millennium Ecosystem Assessment) that ecosystems have been deteriorating over time, the inclusion of ecosystem as capital assets, the growth of wealth per capita will be smaller.

One major objective of our research is to find ways of assessing the accounting prices of ecosystems, that is, the change in future wellbeing from a small perturbation of the system today. In particular, as pointed out earlier it is necessary to include resilience in the capital asset base, and as we have indicated above, we need the accounting price of resilience. Till today, we have formulated a theory only for very simple systems, which implies that it will be a very important issue in the future research.

4.3.3. Socio-political complexity, institutions and governance in ecosystem management.

Most branches of social science have a long tradition of studying environmental problems and politics, but within a steady-state paradigm (Hall 2003), seldom acknowledging the importance of non-linear dynamics, evolutionary processes, and complexity. SMI will build on existing approaches and theories, but in the light of processes of change in complex social-ecological systems. Understanding change from local to global scales requires in-depth analysis of the institutional foundations of ecosystem management, the effect of changing forms of governance, as well as group- and micro-level factors such as social capital, trust, participation, leadership, social memories, and learning processes. We insist that such factors cannot be understood in isolation, but should be investigated as fundamentally interwoven. Such understanding will form a strong basis for implementation of governance systems and management practice in order to secure ecosystem services.

Path dependency, institutional change, and institutional learning.

Institutions are essential in understanding human interaction with ecosystems. The development of common-property theory (McCay & Acheson 1987, Ostrom 1990, Bromley 1992, Hanna et al. 1996) and studies of institutions and community based natural resources management (Baland & Plateau 1996, Berkes & Folke 1998, Fabricius & Koch 2004) have provided tools for addressing the social dimensions of management systems for resources. A central research issue is how ecosystem management institutions evolve, change or rigidify, and interact with a wide array of factors such as ecosystem dynamics, demographical and political change, and technological development. There are a number of transdisciplinary analytic themes that we intend to address in the SMI research activities.

Understanding sources of institutional rigidity and change has attracted vast interest from neo-institutional scholars (e.g. Thelen 1999, North 2000, 2005, Pierson 2000a), not the least as the economic, social and ecological challenges facing the world are likely to require major changes in the incentives actors face, such as the way we organize international cooperation, national legislation, rules and regulations (e.g. Lundqvist 2004, Ostrom 2005, Berkes et al. 2003, Young 2003). How social actors learn and cope with uncertainty and change is crucial for understanding both institutional emergence and policy change (Peters 1999), which can be explained by analyzing how individuals process information, harness uncertainty, and learn from past failures and successes (Mantzavinos et. al. 2004, North 2005).

Inspired by the notion of path dependency in economic sciences (Arthur 1994, North 1990, Magnusson & Ottosson 1997), the concept was rapidly applied within sociology (Mahoney 2000, 2001) and political science (Pierson 2000a, 2000b, 2004, Thelen 1999, Thelen & Streeck, 2005). Path dependency has been employed as a theoretical explanation for institutional inertia observed in empirical studies, where continuously increasing returns create progressively stronger incentives for actors to continue interaction with the existing institutional framework. Path dependency theory stresses the importance of 1) initial conditions of an institutional trajectory, 2) timing and sequence

of events influential for institutional development, 3) non-linear causal flows and non-predictable outcomes of institutional evolutions (Mahoney, 2000; Pierson, 2004). Several models of institutional change has been suggested, e.g. "punctuated equilibrium" (Krasner 1984), "critical junctures" (Collier & Collier 1991, Mahoney 2001), "institutional layering" (Thelen & Streeck 2005), and "policy windows" (Kingdon 2003).

Linking these recent developments in institutional theory to emerging works on institutional diversity and robustness (Low et al. 2003, Ostrom 2005) can make for a fruitful understanding of the basis for the self-organization of institutions in relation to ecosystem management. There is scope for comparison with efforts in resilience research on what has been referred to as the command-and-control pathology of natural resource management (e.g. Gunderson et al. 1995, Holling & Meffe 1996).

The focus on institutions and learning in the social sciences parallels our insights from research on nested social-ecological systems (e.g. Gunderson & Holling 2002, Folke et. al. 2005). There is great scope for analyzing factors that affect policy learning and institutional change from the social sciences (Adler & Haas 1992) in the context of social-ecological systems and ecosystem management. There is also great scope for exploring the impacts of ecosystem dynamics on the collective action problems actors' face, i.e. ecological uncertainty, crises and non-linear behavior on institutional and policy change across political levels. Such feedbacks have only to a limited degree been explored in the collective action literature (Ostrom 1998, North 2005, Sandler 2004). Key areas of research include:

- What are the tradeoffs between learning, flexibility and experimentation and cost-efficiency, legitimacy and transparency in institutions dealing with complex social-ecological systems?
- How are learning processes affected by high social, political and ecological uncertainty?
- What are the prerequisites – e.g. institutional, social, political or economic – for effective and inclusive learning processes?

Governance – changing patterns of social and political organization

The term "governance" has many different meanings and has been employed in a large variety of empirical settings, ranging from studies of local politics to investigations of international organisations (Pierre & Peters 2000, Rhodes 2000). In its most general expression the concept of governance can be understood as "governing without government" denoting some form of coordination of the public sphere taking place outside the conventional legal-bureaucratic framework for public policy formulation (Kjær 2004). Two broad categories can be distinguished: governance as a process of ongoing transformation of the public sphere, most noticeable in changing goals and practices of public management and administration, the structuring of formal bureaucracy, the responsibilities and capabilities of the welfare state, and the powers of the nation state (Stoker 1998). The authority of the nation state is currently being displaced both upwards to new forms of supranational arenas and organizations, and downwards to local and regional governing bodies (Marks & Hooghe 2004) and also sideways through public-private partnerships, privatization and corporate social responsibility (i.e. the market), and through increased public participation, and NGO involvement in formulating and implementing public policy (i.e. civil society). The driving force behind this process seems to be a general weakening of the nation state, both in terms of actual powers and perceived legitimacy, resulting from accelerated globalization. The present transformation process of public governance represents a historically significant change and is therefore likely to fundamentally alter the preconditions of governance for ecosystem management.

Governance is also an analytical concept, where the term is used in the study of policy networks, new forms of public participation in the policy process, and discursive and deliberative policy formations. Governance scholars seek to investigate how policy networks and policy advocacy coalitions are formed and influence policy (Sabatier 1988, 1999), how the policy discourse is

constructed (Fischer 2003, Hajer & Wagenaar 2003), and the emergence of new policy arenas that transcend the borders of the nation state (Bache & Flinders 2004). Theoretical advances in resource management and environmental politics – the ecological modernization school (Barry 2003, Buttel 2000, Lundqvist 2004, Paterson 2002) and the adaptive management approach (Eckerberg & Joas 2004, Lee 1999) can be placed within a more overarching governance paradigm.

A related concept is good governance, often used as an umbrella-term for research focussing on the quality of central governing institutions, in terms of absence of corruption, predictability, effectiveness, transparency, impersonality, and adherence to the principles of rule of law (Feng 2003, Paavola & Adger 2005, Rothstein 2003). Scholars seek to understand variations in the quality of governance found among and within nations, and how good governance is related to things such as poverty alleviation, human well-being, and environmental management (Easty & Porter 2005, Welsch 2004). The challenge ahead is to analyze;

- Does the erosion of the nation state and formal bureaucracy means a weakening of society's capacity to adapt to ecosystem changes that require large-scale and general societal responses (e.g climate change and green house gas reduction)?
- Or will society's adaptive capacity strengthen when command-and control natural resource management shifts into increased stakeholder involvement, self-organization and institution-building, learning processes, cross-scale network formations, and more flexible and trial and error-based forms of management schemes for local and regional ecosystems?
- How is self-organization enabled or hindered, and how can social-ecological resilience be strengthened or undermined depending on the quality of the surrounding institutional frame work? How can polycentric institutions be established in a context of poor overall institutional quality?

Legitimacy and accountability

Good governance of ecosystems has been interpreted as solving the trilemma characterized by tensions between effectiveness, participation, and legitimacy (Lundqvist 2004). In self-organized governance systems there may be a trade-off between legitimacy and accountability. To the extent that the most affected stakeholders are involved and can influence the management, legitimacy is enhanced. At the same time, accountability becomes less straight-forward.

The self-organization may in itself also threaten the legitimacy if stakeholders with superior political and economic power are able to marginalize other stakeholders, observed in participatory projects in low-income countries (Agrawal & Gibson 1999, Brown 2002). Experiments in high-income countries with new governance systems for ecosystem management based on collaboration and sometimes even co-management have often enhanced legitimacy (Wondolleck & Yaffee, 2000, Hahn et al. 2006). Self-organizing networks may also enhance legitimacy and effectiveness of ecosystem management in low-income countries (Pretty 1995). Our preliminary findings suggest that informal network structures do not replace the accountability of existing hierarchical bureaucracies but operate within and complement them.

- How can democratic processes be sustained when subject to informal structures and institutions?
- Are flexible self-organized management systems more open to vulnerability of rent seeking or corruption?

Cross-scale challenges

Existing cross-scale interactions in complex social-ecological systems pose a fundamental yet poorly elaborated challenge for governance theory. Despite the importance of cross-scale linkages and feed-backs in nested social-ecological systems (Crumley 2001, Gunderson & Holling 2002), theory development in the social sciences has been poor and our understanding of how actors across scales (such as from local-national-international) interact strategically and produce political outcomes relevant for ecosystem management is still underdeveloped.

Some advances have been made in understanding political processes where actors interact across scales simultaneously, like the impacts of "nested games", or "interconnected games" (e.g. Tsebelis 1990, Putnam 1988, Hanf & Underdal 1998). Other advances have been made in understanding the linkages between institutions across scales, often denoted "multilevel governance" (e.g. Hooghe & Marks 2003, Yee 2004). In addition, progress has been made in understanding the logic and impacts of international regimes – that is international institutional arrangements designed to tackle transnational challenges by encouraging behavioural changes at domestic level (Krasner 1982, Young 1989). The ability to use institutions effectively, at organizational levels appropriate to the ecological scale of environmental change, is referred to as scale-matching (Lee 1993) or institutional fit (Folke et al. 1998, Brown 2003). Attempts have been made by the Millennium Ecosystem Assessment (2005) to factor in ecological dimensions by bringing together cross-scale assessments through the use of scenarios (Carpenter et al. 2006).

We are only at the beginning of linking advances in the social sciences with the understanding of the importance of cross-scale interactions in social-ecological systems. Even if we have a good overview of types and sources of multi-level institutions (e.g. Yee 2004, Hooghe & Marks 2003), it is unclear how these affect the ability of societies and ecological systems to tackle the possible impacts of global environmental change - such as extreme weather events, surprises in both ecological and social systems, and regime shifts in ecosystems (e.g. Scheffer et. al. 2001).

Despite that complexity theory has gained a wide interest in many scientific disciplines, little research has been undertaken on complexity in social systems such as multi-level institutions, and regime theory (Jervis 1997, Ostrom 2005). We see a number of potentially interesting insights applying transdisciplinary assumptions of complex and adaptive systems, characterized by historical dependency, nonlinear dynamics, threshold effects, multiple basins of attraction, and limited predictability. Identified interesting research areas include:

- What are the impacts of the diversity of multi-level institutional settings on the capacity of social-ecological systems to cope with global environmental change?
- Which are the characteristics of multi-level institutions that are robust to surprises, crises and change?
- How is the strategic interaction among political actors across political levels affected by social-ecological uncertainty, complexity and surprises?
- How do the interactions of actors across institutional levels - intentionally or unintentionally - enhance or undermine the capacity of social-ecological systems to cope with surprises and stresses?

4.3.4. Knowledge systems and adaptive management

The lesson from complex systems thinking is that management processes can be improved by making them adaptable and flexible, able to deal with uncertainty and surprise. Holling (1978) recognized early on that complex adaptive systems required adaptive management. Adaptive management differs from the conventional practice of resource management by emphasizing the importance of feedbacks from ecosystems in shaping policy, where policies become hypotheses and management actions become the experiments to test those hypotheses (Walters 1997). Since the self-organizing properties of complex adaptive ecosystems and associated management systems cause uncertainty to grow over time, understanding should be continuously updated and adjusted and each management action viewed as an opportunity to further learn how to adapt to changing circumstances (Carpenter & Gunderson 2001).

Knowledge and learning

Centrally-controlled ecosystem management often fails because planners view the management as a solution to a problem. In contrast, adaptive approaches view management as an opportunity to search for solutions in a situation where uncertainty is high and control points are few (Gunderson et al. 1995). Knowledge acquisition of complex adaptive ecosystems is an ongoing, dynamic

learning process, and such knowledge often emerges over decades with people's institutions and organizations (Muchagata & Brown 2000). Learning for ecosystem management is often viewed as a social process referred to as social learning (Lee 1993, Clark et al. 2001). Social learning theory was developed in psychology (Rotter 1960, Bandura 1977) and later in political science and sociology (e.g. Habermas 1984, May 1992). The social context of learning is further stressed in the literature on organizational learning (Westley 1995) with changes in mental models and meaning referred to as "double-loop learning" applied in relation to ecosystem management by e.g. Blann et al. (2003).

Facing complex adaptive systems expands the role of the scientist in policy and decision making from providing expert knowledge as a detached specialist to becoming one of several actors in the learning and knowledge generation process (Ludwig et al. 2001, Kinzig et al. 2003, Kates et al. 2001). Efforts are taking place to mobilize, make use of and combine different knowledge systems and learning environments to enhance the capacity for dealing with complex adaptive systems and uncertainty (Agrawal 1995, Gadgil et al. 2000, Armitage 2003, Brown 2003). Complexity draws attention to the fact that local knowledge and traditional knowledge and management systems could be seen as adaptive responses in a place-based context and a rich source of lessons for social-ecological adaptations (Berkes et al. 2000). There is a growing literature with cases that combine traditional knowledge and local knowledge systems with scientific knowledge to cope with change in resource and ecosystem management (e.g. Aswani & Hamilton 2004, Becker & Ghimire 2003). More broadly, however, there remain cultural barriers that include differences in ideas, practices and expression of interests over fundamental concepts and visions (Castro and Nielsen 2001, Kendrick 2003, Ellen et al. 2000). How to use and combine multiple knowledge systems in ecosystem assessments and management has recently been addressed in the Millennium Ecosystem Assessment (Ericksen, Woodley et al. 2005, www. maweb.org).
We postulate that the way such knowledge is being organized and culturally embedded and its relationship to institutionalized, professional science, have an essential role in catalyzing new ways of managing environmental resources.

Crisis and management practice
Crisis, perceived or real, seems to trigger learning and knowledge generation and opens up space for new management trajectories of resources and ecosystems (Berkes et al. 2003). For example, Olsson & Folke (2001) described the emergence of an ecosystem-based management system of Lake Racken catchment, and illustrated how crisis opened up trajectories of social self-organization and learning for the management of ecosystem services. Berkes & Folke (2002) identified management practices of traditional communities that cope with periods of rapid change and divided them into practices that evoke change, that survive change and that nurture sources for reorganization following change. Such management practices are largely absent in conventional management and seem to have developed as a result of selection through experience with change and crisis.

- What are the barriers and bridges for innovation of management and governance following crisis and change?
- Can crisis be governed to trigger change into new development directions for ecosystem management?

Participation
Local participation and collaboration is well established and can no longer be ignored even in otherwise top-down dominated environmental management (Fabricius & Koch 2004). Local participation is often included in policy documents and actual planning and execution of new management regimes in e.g. integrated water management and nature conservation. A number of techniques – such as Rapid Rural Appraisal and Participatory Rural Appraisal – have been developed to aid in participatory research, as well as in research on the issue of participation (Chambers 1983, 1997).
By combining theories and methods from different disciplines, by looking at linkages across spatial scales as well as temporal dimensions, and by including local actors in the research process, many aspects of social-ecological dynamics that previously had been ignored are brought to the

front. These include issues of power, of gender, of social networks, of risk-spreading and resilience, of formal and informal institutions (Scoones 1994, Leach & Mearns 1996, Dahlberg & Blaikie 1999, Mortimore & Adams 1999). It is an important area of research that we tend to further develop.

In Sweden – and most democracies in northern countries –the discussion of the role of local participation and collaboration across societal levels has a much shorter history. The Swedish Environmental Protection Agency has recently published a report on local support for environmental conservation in Sweden. The significance of participation and cross-scale collaboration has been emphasized in the new European Water Directive. Another arena where the issue of participation has recently been highlighted is in connection with different forms of nature conservation, e.g. World Heritage Sites, biosphere reserves, and national parks. Still, there are limited insights in what foundations to build on when it comes to including local stakeholders. The Stockholm group has research experience with different aspects of collaboration and participation in various parts of the world, including Sweden, with insights that can be fed into processes of adaptive governance and other approaches. The following research question will be addressed:

- Is there a limit to the extent of participation possible to avoid that conflict resolution and decision making processes lose their ability to respond to sudden and surprising events? What are the tradeoffs?
- During what circumstances and conditions does participation serve as a source of resilience or source of vulnerability?

4.3.5. Actors, networks, and multilevel dynamics of social-ecological systems

Social memory and reorganization following change

A crucial challenge for adaptive capacity during periods of rapid change seems to be the mobilization of social memory (Halbwachs 1925, Olick & Robbins 1998, Gongaware 2003) or the arena in which captured experience with change and successful adaptations, embedded in a deeper level of values is actualized through community debate and decision-making processes into appropriate strategies for dealing with ongoing change (McIntosh 2000, Crumley 1994). Social memory is important for linking past experiences with present and future policies and helps provide a foundation for sense-making, meaning and modification of rules. The social memory of past changes in ecosystems, and responses to these, can be mobilized and fed into processes where structures of governance of ecosystem are decided, management practices worked out, and conflicts resolved. The sources of social memory and their relations to governance and management of ecosystem services during periods of gradual and rapid change will be further explored in our research. Research questions here include:

- Can we learn from accumulated experience in societies that historically have been struck with sudden change?
- How have these societies embedded their experience in institutions and organizations to reduce vulnerability?
- Whar role does institutional and organizational redundancy play as part of social memory for ecosystem management policies?

Social capital and trust

The core idea of social capital theory builds on the observation that a vast number of social interactions require the cooperation of individuals for whom it might not always be rational to take part in the cooperative endeavor (Coleman 1988, Putnam et al. 1993). Social capital theory holds that factors such as trust, organizational networks, and norms of reciprocity are highly influential for achieving large-scale cooperation (Ostrom 2000). Economies with high levels of social capital seem to be more flourishing (Knack & Keefer, *1997,* Rothstein 2003), democratic participation and governance tends to be more effective and dynamic (Knack 2002, Putnam 2000, Putnam et al. 1993). Given the fact that resource management often entail elements of social

collective action dilemmas, social capital must be considered highly relevant for understanding both emergences of adaptive management schemes as well as the outcome of such management policies (Pretty & Ward 2001).

High levels of social capital within a group can under certain circumstances serve to perpetuate power relations, foster distrust against outsiders, impede social and institutional change, and work as an obstacle for implementation of environmental reforms (Lundqvist 2001). Some forms of social capital can have beneficial effects, whereas others might have adverse impacts on the possibility of adopting adaptive management schemes. Is it always possible to strengthen social capital in a community by introducing joint management of natural resources, or is high levels of social capital an indispensable prerequisite for adaptive management? To better understand the linkages between norms regulating cooperation and management of complex ecosystems, the following research questions are central:

- What types of social capital are related to the capacity of communities to engage in adaptive management of natural resources on a local scale?
- What is the role of institutional (vertical) trust for resource management?
- How is social capital created, maintained, and destroyed in situations of local resource management?

Leadership, actor groups and bridging organizations

Agents such as leaders can activate a potentially latent stock of social capital and use it to produce a flow of benefits (Pinkerton 1998, Westley 2002). Crises open up arenas for new leadership shaping change and reorganization, including the role of policy or public entrepreneurs. Entrepreneurial leaders have proven their significance in the development of international institutions by functioning as agenda setters, popularizing issues at stake, devising policy options to overcome bargaining impediments, brokering deals, and lining up support for salient options (Young 2002). Different agents/actors or teams/actor groups play significant roles, as part of social memory, in mobilizing social networks to deal with change and unexpected events, and also create rapid change (tipping pints) and to reorganize accordingly (Guimera et al. 2005, Gladwell 2000, Scheffer et al. 2003). They include brokers, that bring in new ideas and networks of contacts (Bebbington 1997, Long 2001, Sverisson 2005), knowledge carriers and generators, sense-makers, interpreters, facilitators, visionaries, inspirers, innovators, experimenters, followers and reinforcers (Folke et al. 2003). Social capital focuses on relationships among such groups, i.e. the bridging and bonding links between people in social networks. Boundary and bridging organizations can serve as filters for external drivers (Alcorn et al. 2003), provide opportunities by bringing in resources, knowledge, and other incentives for ecosystem management (Cash & Moser 2000) and arenas for trust-building, sense-making, learning, vertical and/or horizontal collaboration, conflict resolution and facilitate adaptive and innovative responses (Folke et al. 2005).

How to stimulate the emergence, formation and collaboration of different actors groups in networks for dealing with uncertainty and change are important research issues for sustainable governance and management and a critical factor for learning and nurturing integrated adaptive responses to change.

- How does leadership emerge in new situations where clear norms for leadership are lacking? Are there social mechanisms that increase the chances for leadership to emerge? Are there ways to institutionalize, diversify and secure leadership functions? Dynamics of group leaders, and power struggles, how does this affect resilience of the system?
- In what way do combinations of social roles of agents/actor and team/actor groups, their diversity, overlapping functions, and redundancy provide resilience for reorganization, and enhance adaptive capacity in the face of disturbance and crisis?

- When do their combination cause barriers, collision and erosion of social capital and social memory, as may be the case when different cultural value systems, worldviews and discrepancies in conceptualization are brought together and interact?

Social networks
In network theory, networks are graphical representations of agents (nodes) and their interactions (links). Network analysis is widely used in the context of social-ecological systems but most network studies focus on static networks with a low degree of heterogeneity among the nodes and links. From a resilience perspective, it is necessary to develop analyses which include dynamic aspects as well as heterogeneity (Janssen et al. 2006). For example, nodes and links are not always active. Some are sleeping nodes and links that are activated only in specific situations, like a crisis. Maintaining the capacity to reactivate these nodes and links in times of crisis is an important contributor to the systems resilience. When nodes or links disappear from a system, it seems that one characteristic of a resilient system is its capacity to fill up the empty space with new nodes and links. Furthermore, Bodin and Norberg (2005) showed that in networks where some agents can do independent experimentation while others share their experience, efficient resource use and resilience emerge.

Networks of collaboration may emerge from different actors and levels and expanding and linking networks of dependence and exchange helps facilitating integrated and inclusive management (McCay 2002). Deep understanding of the processes involved in social network dynamics are needed when shifting from top down management by imposed regulations towards governance designs that enable self-organized sustainable practices (Janssen et al. 2006). Social networks can be key mechanisms for mobilizing social memory at critical times and enhance information flow and collaboration across scales. Our work will expand the analysis of social-ecological systems into the emergence and dynamics of networks:

- How do network structures relate to periods of gradual and rapid change?
- In what ways can they dynamically connect across scales and organizational levels to improve ecosystem management?

Adaptive co-management and adaptive governance
Ecosystem management (a) emphasizes the need to include humans as part of ecosystems, (b) includes the institutional aspects of management by addressing different levels of decision making, (c) states that there are limits to knowledge when dealing with complex dynamic systems, and (d) recognizes the need for adaptive learning processes to develop policies that are more in tune with ecosystem dynamics. It calls for a participatory approach in research and development of ecosystem management that includes resource users; their knowledge, experience, and practices; and the norms and rules these practices are embedded in (Christensen et al. 1996, Dale et al. 2000). The World Resources Institute (2000) and United Nations Environment Programme (1998) and UNESCO (1999) explicitly include these aspects in their definitions of ecosystem management.
Adaptive co-management combines the dynamic learning characteristic of adaptive management with the linkage characteristic of co-management (Carlsson & Berkes 2005). It relies on participation and collaboration among a diverse set of actors operating through social networks (Olsson et al. 2004) and gives local resource users the opportunity to influence decisions regarding the future of the environment in which they live and operate (Borrini-Feyerabend et al. 2004). Adaptive co-management is an emergent property of resource management systems, not an arrangement that can easily be legislated top-down, but one that self-organizes bottom-up.

Dietz et al. (2003) used the concept adaptive governance to expand the focus from adaptive management of complex ecosystems to start to address the broader social contexts that enable ecosystem-based management. We see adaptive co-management as an operationalization of adaptive governance for the management of ecosystem services (Folke et al. 2005). Adaptive governance generally involves polycentric institutional arrangements, which are nested quasi-autonomous decision-making units operating at multiple scales (McGinnis 2000) and aim at finding a balance between decentralized and centralized control (Imperial 1999). Adaptive governance of complex systems brings together research on institutions and organizations for collaboration, collective action and conflict resolution in relation to natural resource and ecosystem management.
The essential role of individuals is recognized in this context (e.g. leadership, trust building, vi-

sion and meaning), their social relations (e.g. actor groups, knowledge systems, social memory) and social networks serving as the web that tie together the adaptive governance system. Successful transformations towards adaptive governance for ecosystem management seem to be preceded by the emergence of informal networks, orchestrated by key individuals, that help to facilitate information flows, identify knowledge gaps, and create nodes of expertise of significance for ecosystem management that can be drawn upon at critical times (Folke et al. 2005). The notion of adaptation implies capacity to respond to change, like climate change or political change, and possibly even transform social-ecological systems into improved trajectories (Adger 1999, Rockström 2003, Adger et al. 2005).

In the research program we intend to further study governance systems that operate at multi-levels in a dynamic fashion and we will participate in adaptive co-management schemes in Sweden and elsewhere and in the context of the cross-cutting research themes.

- What are the social mechanisms and socio-political and economic features that make adaptive governance viable in the face of uncertainty and sudden change?

4.3.6. Adaptive capacity to deal with uncertainty and change

Lots of efforts may be put in place to support the emergence of adaptive governance for management of ecosystems, and such governance may perform quite successfully during periods of gradual change. But rapid change may challenge the whole governance system. Hence, a major question for sustainable governance and management of linked social-ecological systems is whether the collective capacity to perform adaptive governance is strengthened or eroded in the face of sudden change?

Vulnerability, adaptability, resilience

Adaptive capacity in social-ecological systems for dealing with uncertainty and change is central in relation to complex adaptive systems and cross-scale interactions. Vulnerability is the state of susceptibility to harm from exposure to stresses associated with environmental and social change and from the absence of capacity to adapt (Kasperson et al. 2005, Downing 2001). Vulnerability research emphasizes the importance of addressing both the role of external forces and rapid change in reshaping social-ecological systems and the different capacities of agents/actors in the system to respond to change based on their access to social and biophysical capital (Turner et al. 2003). Research on vulnerability has grown out of several different areas spanning natural hazards, food insecurity, poverty, livelihoods and climate change (Adger 2006). Vulnerability to food insecurity is explained, through entitlement theory, as a set of linked economic and institutional factors (Sen 1981), which displaced prior notions that shortfalls in food production through drought, flood, or pest, were the principal cause of famine. Livelihood specialization and diversity are important elements in vulnerability to drought with social capital and social relations that translate these parameters into vulnerability of place (Eriksen et al. 2005). Developing countries are often deemed to be more vulnerable to climate change compared to developed countries, partly because of their exposure but mainly because of their limited adaptive capacity (Downing et al. 1997).

It is increasingly understood that resilience of social-ecological systems is critical for livelihoods, poverty reduction, and disaster preparedness. Whereas some connections of ecosystem change to disasters are evident, we have little quantitative information with which to measure the disaster risks associated with ecosystem change and regime shifts. Fundamental research is needed in this area. Such research could improve adaptive capacity to mitigate future disasters, improve quantitative risk assessment, and make it possible to include ecosystem services in, for example, actuarial and insurance markets.

Adaptive capacity is a system's ability to deal with exposure or risk (Smit & Wandel 2006), to evolve in order to accommodate environmental hazards or policy change and to expand the range of variability with which it can cope (Adger 2006). The IPCC defines adaptive capacity (to climate change) as the ability of a system to adjust to climate change (including climate variability and

extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences. Some authors apply "coping ability" to shorter term capacity or the ability to just survive, and employ "adaptive capacity" for longer term or more sustainable adjustments (Vogel 1998).

Systems with high adaptive capacity are likely to be more able to re-configure themselves when subject to abrupt change without significant declines in crucial functions of the social-ecological system. Addressing how people respond to periods of rapid change and how society reorganizes following change is an important area of research that is increasingly in focus (Adger et al. 2005). Based on a synthesis of several case studies, Folke et al. (2003) identified and expanded on four critical factors that interact across temporal and spatial scales and that seem to be required for adaptive capacity in social-ecological systems during periods of rapid change and reorganization: learning to live with change and uncertainty; nurturing diversity for renewal and reorganization; combining different types of knowledge for learning; and creating opportunity for self-organization towards social-ecological resilience.

The International Human Dimensions Program on global environmental change (IHDP) invited state of the art contributions on adaptive capacity, vulnerability, and resilience as well as of the networks of researchers in these areas, to appear in Global Environmental Change (Janssen & Ostrom 2006). In the proposed research program we intend to take these efforts and exciting area of research substantial steps forward.

Social drivers of change and ecosystem services

There are numerous situations where human behavior unconsciously contributes to a modification of important variables (like nutrients and freshwater flows or biological diversity) that support ecosystem services and structure and sustain desirable ecosystem states For example, policies and decisions on financial markets or in urban areas may cause land use change, redirection of freshwater flows or loss of functional groups of species elsewhere and thereby impact on resilience. In such situations, society alters its adaptive capacity to surprise and crisis but people are often ignorant about it, because they do not perceive feedbacks on changes in ecosystem services of their own actions (Lebel et al. 2003, Young et al. 2006). We intend to use and develop social science theory in the analyses of these problems, aiming at new cross fertilization between social sciences, humanities and natural science and in relation to adaptive capacity, vulnerability and resilience.

There exists lot of work analyzing social forces that shape landscapes and seascapes, which illustrate that popular statements about the negative effects of human population growth, poverty, or economic activities on resource and ecosystems are much too simplistic (e.g. Widgren & Sutton 2004). The patterns behind drivers of change are complex and concern multiple causes and synergetic factor combinations of e.g. resource scarcity leading to an increase in the pressure of production on resources, changing opportunities created by markets, outside policy intervention, loss of adaptive capacity, and changes in social organization and attitudes. Weak state economies; institutions in transition or absent in developing regions; induced innovation and intensification, especially in peri-urban and market accessible areas of developing regions; urbanized aspirations and income with differential rural impacts; new economic opportunities linked to new market outlets, changes in economic policies or capital investments; and inappropriate intervention are examples of features that give rise to rapid modification of ecosystems, landscapes and seascapes (Lambin et al. 2003). But there are local cultures (including class and gender orders) that have the adaptive capacity to reinterpret and absorb influences from both national and global levels (Rogers 1991).

Different perspectives of analyzing social drivers tend to follow different lines of explanation of the reasons of ecosystem change because each tends to focus on certain organizational levels and temporal scales of the social-ecological system. There is great scope to develop integrated theory by combining perspectives that e.g. address gradual and progressive processes of change at the

scale of large entities, with agent-based approaches that deal with people's own foreseeable futures and with narratives that often adopt longer time horizon and address critical events and abrupt transitions. We intend to further develop the collaboration on such issues that we have with the IHDP, IGBP and other actors of the ESSP, where land-use changes are now increasingly analyzed as part of the dynamic and co-evolving social-ecological system.

Human societies respond to ecosystem change through multiple pathways including collapse or failure, migration, and creative invention through discovery. Extreme drought, for instance, has likely triggered both social collapse and ingenious management of water through irrigation systems. Future response and feedbacks between the human and environmental components of the Earth system will benefit from understanding of the past and adaptation to future surprises. Research challenges are numerous and include efforts clarifying the feedbacks of social-ecological systems, the ones that cause vulnerability and those that build resilience, how they interplay, match and mismatch across scales and the role of adaptive capacity in this context. The collaboration with the program 'Integrating history of people and the environment' (IHOPE) and its focus on long temporal scales of complex adaptive social-ecological systems will be very valuable in this context.

Scenarios for adaptive capacity and trajectories towards adaptive governance
Work on scenarios has expanded considerably as a tool for envisioning the future and was a core part of the Millennium Ecosystem Assessment, where the scenarios considered a full range of social and ecological drivers of change, particularly at global scales, including the social processes which influence human actions and ecosystem dynamics that directly alter flows of ecosystem services (Carpenter et al. 2006). Scenarios work at regional and local scales are part of creating vision, meaning and direction for policy and governance. Developing scenarios may be a way to address uncertainty when controllability is very low and thereby complements adaptive management strategies and governance approaches (Fig. 4.2). In our work we have found that scenarios may be a way to break the ice between conflicting interests in ecosystem management, trigger participation, find mutual interests, and create arenas for collaboration with shared visions.

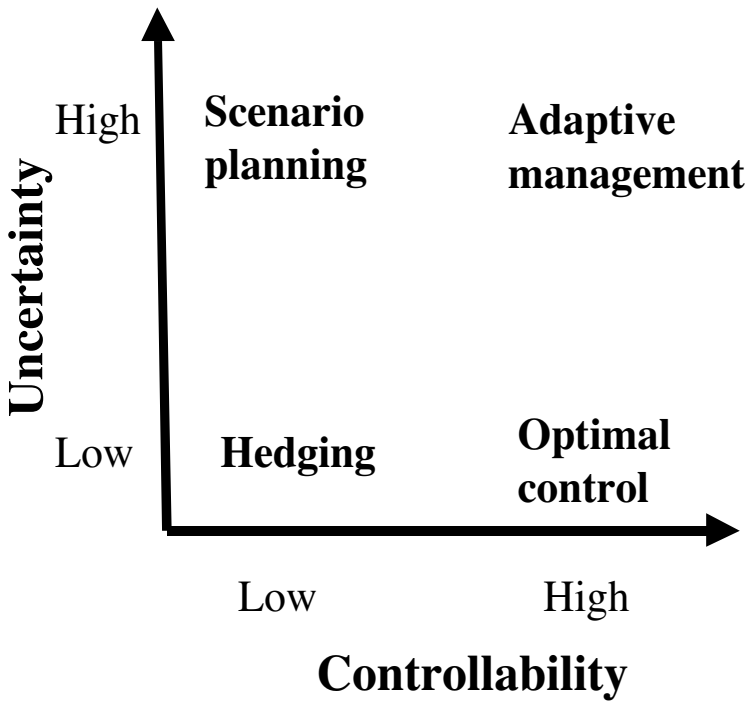


Fig. 4.2 The choice of management strategies depending of level of controllability and uncertainty (modified after Peterson et al. 2003)

The overall perspective of the research agenda presented above is the need to fundamentally change the view of management and governance from assuming that the world is basically in steady state and searching for optimal solutions to control change. This map of the world does no longer fit with reality. We intend to develop research insights and policy guidance to confront the situation of a planet facing major change. We believe that it requires accepting a world of complex systems and cross-scale interactions where change is the rule rather than the exception and were the challenge is to sustain desirable social-ecological trajectories and even transform society into improved pathways of development subject to continuous uncertainty and change.

The different parts of the research agenda will run in parallel and feed into each other. They address in an integrated fashion the interplay between social and ecological systems from understanding the biophysical foundation for the generation of ecosystems services, how it is shaped by human actions, the implications of the complex dynamics for economic welfare theory and policy, the adaptive management challenges, including participation, learning and acknowledgement of the role of diverse knowledge systems, the governance challenge including the emergence of institutions, institutional change, and multilevel and adaptive governance to addressing adaptive capacity in the context of vulnerability, sources of resilience (e.g. social memory, social capital, actors, networks) and drivers of change.

The insights of the research will continuously feed into the cross-cutting themes and vice versa. We expect to continue to produce top quality scientific output ranging from experiments and fieldwork, theory development to transdisciplinary analyses and syntheses. In parallel, the results will feed into a broad set of policy arenas and the research will also be shaped by participatory processes with actors and stakeholders in systems of adaptive co-management and governance.

4.4 Cross-cutting themes for learning and application

The perspective presented here implies that achieving desirable outcomes for humanity, such as those of the UN Millennium Development Goals on poverty, food security, and environmental sustainability will require new integrated and adaptive approaches to social and economic development, where the complex interconnectedness of social-ecological systems, across scales, is considered and the existence of uncertainty and surprise accepted as the rule. Therefore, a major challenge is to develop governance systems that make it possible to relate to complex and dynamic environmental assets in a fashion that secures their capacity to support societal development for a long time into the future. It will require adaptive forms of governance of social-ecological systems.

The implication for policy is profound and requires a shift in mental models towards human-in-the environment perspectives, acceptance of the limitation of policies based on steady-state thinking and design of incentives that stimulate the emergence of adaptive governance for social-ecological resilience of landscapes and seascapes. Not only adaptations to current conditions and in the short term, but how to achieve transformations toward more sustainable development pathways is one of the great challenges for humanity in the decades to come.

4.4.1 Urban social-ecological systems and globalization

The mission

The rapid increase of large cities in the developing world and the transformation of urban landscapes in the developed world represent one of the greatest challenges to ensure basic human welfare and a viable global environment. Urbanization and urban landscapes was recently identified by the Millennium Ecosystem Assessment as a priority area where large knowledge gaps exists (MA 2005). Within the framework of this program we are proposing to mobilize world leading research groups, policy makers and practitioners in cities around the world in a dynamic collaboration to analyze and understand resilience in urban social-ecological systems. Research will be conducted with and at local communities to ensure that outcomes can be translated into tangible action and inform local, national and international policies.

The challenge

Half of the world's population today lives in urban landscapes, a proportion increasing to 2/3 within 50 years. Most of this growth will occur in developing countries (see figure 4.3) and in 2030 it is estimated that more than two billion people will be living in urban slums with limited access to basic services, limited participation in decision making processes and facing extreme vulnerability to natural disasters. Urbanization is a global multidimensional process which manifests itself through rapidly changing population densities, changing land cover and a diversity of cultural practices.

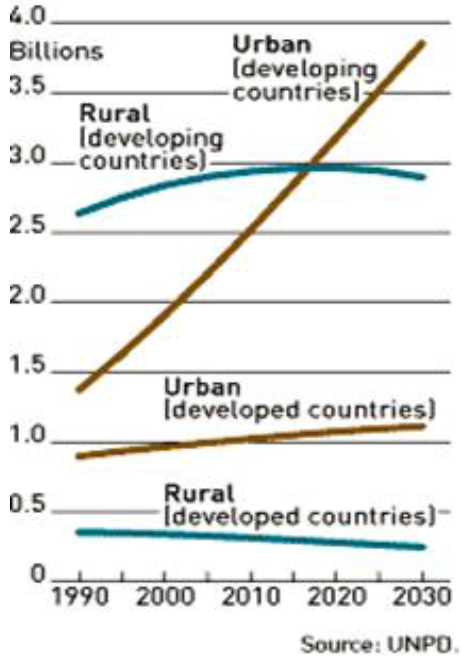


Fig. 4.3. Development of urban and rural populations 1990-2030. The growth of cities is primarily due to a combination of four forces: natural growth, rural to urban migration, massive migration due to extreme events, and redefinition of administrative boundaries. Urban landscapes represent probably the most complex mosaic of land cover and multiple land uses of any landscape. As such, urban landscapes provide important large-scale probing experiments of the effects of global change on ecosystems since e.g. significant warming and increased nitrogen deposition already are prevalent and because they provide extreme, visible and measurable examples of human domination of ecosystem processes.

Urbanization proceeds in a variety of ways in different parts of the world and affects the environment at all scales. In the developed countries, as well as in developing countries where the Millennium Development Goals are a primary target, urbanization places increased pressures on vulnerable social systems and ecosystems. But cities are also places offering solutions for humans and the environment since they represent main hubs of knowledge, resources and innovations. For these very reasons it is evident that a much deeper understanding and capacity to adapt to the urbanization process is key to sustainable development. However, current efforts and plans for 'sustainable cities' frequently lack a sound scientific basis and either stop at the city boundary or include the hinterlands only through a simple footprint analysis (McGranahan et al. 2005).

The Research questions

I. What are the main social-ecological drivers of change on global, regional and local scales impacting urban landscapes?
   Factors influencing environmental change in urban landscapes often may originate far beyond city, regional or even national boundaries. Fluctuation in global trade, civil unrest in other countries, health pandemics, natural disasters and possibly climate change and political decisions are among the factors driving social-ecological transformations of the urban lands cape. As developing countries go though unprecedented rate of urbanization, the inequity gap between the prosperous and aging citizens of the North and the disenfranchised population in swelling informal settlements in the South will not only increase but also become more visible. Within the next ten years population movements within and across continents will accelerate and exacerbate current pressures on land, ecosystems and natural resources. Long term planning for good governance of urban landscapes requires an under standing of these global, regional and local forces and their integration into planning at an appropriate scale.

II. What is the role of ecosystem services in promoting human well being and in reducing vulnerability and building resilience of urban systems?
Urbanization creates new types of landscapes, which are often diverse mosaics of different land-uses and habitats. Urban green spaces in all their manifestations (e.g. parks, gardens, green roofs, urban farms) are by their very nature highly patchy and also highly dynamic, influenced by both biophysical and ecological drivers on the one hand and social and economic drivers on the other. Urban landscapes present novel ecological conditions such as rapid rate of change, chronic disturbances, a high ratio of exotic species, and complex interactions between patterns and processes. This together with fragmentation affects the capacity of urban ecosystems to generate desired ecosystem services. Urban landscapes e these changes. With increasing and rapid environmental change in urban areas and in the hinterland, the ecosystem services generated by urban ecosystems are undergoing rapid transformations. Increased scientific understanding and evaluation of urban ecosystem dynamics will result in land-use plans and policies that are proactive rather than reactive thus providing stewardship before restoration is necessary. Such proactive approaches include testing and evaluation of urban design-structures for allocating landscape patterns and ecological processes that build resilience in urban ecosystems (e.g. Felson & Pickett 2005). Successful management of urban ecosystems will ultimately rest on a scientific, social and political capacity to understand and respond to the diverse forces shaping environmental change in time and space.

III. What are the spatial, jurisdictional and temporal scales required to ensure sustainable management and governance of urban landscapes?
Scales mismatch are often the source of maladapted land use decisions in urban landscapes. Competing, overlapping jurisdiction between local, regional and national levels often lead to inadequate mandates and insufficient human and financial resources where and when they are most needed. The footprint of large cities need to be considered globally as changes in urban policies and consumption patterns may lead to booms or bust cycles in rural communities far remote from the urban center. Sound management of urban landscapes requires apprehension of a temporal scale that captures culture, history and an understanding of the way people connect with nature.

IV. In an increasingly complex world where sources of knowledge and legitimacy are multiple and diverse, how are urban knowledge networks able to organize and function to leverage change in institutions and governance?

Governance is no longer the exclusive prerogative of central governments. Local authorities are acquiring more autonomy on land use and the environment. The civil society represented by NGOs, universities, research centers, foundations and even informed citizens are increasingly informing and shaping decision making, institutions and land use practices in urban landscapes. The challenges posed by the rapid pace of urbanization and related impacts on the environment require networks and institutions that are able to capture and share knowledge in a transparent fashion, adapt to social-ecological changes and build the capacity for long term observation, monitoring and prospective. The role of local, regional and international networks in defining common grounds on institutions and governance systems required for sustainable management of urban landscapes need to be better understood and utilized by various levels of governments.

The Research process

The questions will be empirically analyzed in a selected number of urban landscapes around the world, hereafter called the network of research hubs. Each hub will be responsible for a specific theme related to the overarching questions. Participation in the network will contribute to the overall progress of policy relevant research. The tools used for addressing the research questions include mapping, remote sensing analyses of changes and transitions in urban landscapes, modeling using demographic data and social surveys for analyzing structures and dynamics of networks in cities.

The planned activities within the proposed Mistra Institute will build on an established knowledge network of cities, the Columbia University/UNESCO Joint Program on Biosphere and Society), CUBES (www.earthinstitute.columbia.edu/cubes). Between 2001 and 2005, CUBES developed a network of cooperation for supporting globally relevant local strategies for poverty alleviation, environmental sustainability, social inclusion, and conflict mitigation. It developed a rather strong urban focus and established partnership with cities such as New York City, Chicago, Cape Town, Istanbul, and New Orleans among others (Alfsen-Norodom 2004). Phase one of CUBES has now ended and it is proposed that in its second phase the project integrates within SMI. This phase, coordinated by Christine Alfsen at UNESCO, will represent an expansion of the research component as well as the strengthening of networking among sites.

The proposed research is also linked to a number of other global initiatives on interdisciplinary urban research. Diversitas is currently developing a science-plan for urban issues within the core project bioSUSTAINABILITY (www.biosustainability.org). The International Human Dimension Program has recently published a science plan on urbanization. The Resilience Alliance (www.resalliance.org) has drafted a program for addressing resilience and vulnerability in urban landscapes and UNESCO Man and the Biosphere Program (www.unesco.org/mab) is in the process of developing a six-year research program on the applicability of the biosphere concept to urban areas. The Megacities projects under the SEI Urban Environment program has addressed environmental and health issues in Accra, São Paulo, Jakarta, Port Elisabeth and recently suggested an sustainable urbanization strategy for China. There are numerous similarities and potential synergies between these initiatives and these will be expanded through broad collaborations and joint efforts during the initial build up phase of the Institute.

The Research Plan 2007-2009

During the build-up phase the four research questions will be applied in a limited set of cities around the world. The experience from the initial phase will form the basis for an expansion and inclusion of other cities, research groups and networks with a focus on urban studies. The Stockholm Mistra Institute will function as the global hub of the network and will provide local knowledge hubs with access to peer reviewed knowledge, publications, courses and research groups. The network will highlight the value of local knowledge to the governance of socio-ecological systems and provide leverage for changes in policies and institutions through global networking.

Interactions between the global hub and the local knowledge hubs will be organized in the first phase of the project through: **thematic seminars** with the participation of the scientists and the policy makers involved in the network, **on-site field seminars** and field placement for graduate researchers. The next phase of the project will build a **virtual knowledge portal** aimed at linking people and knowledge at sites to the global community. Activities of local hubs will include supporting public and private initiatives for poverty alleviation and environmental management, watershed management to secure drinking water supply and knowledge management to build resilience against natural disasters among others. The policy research component will build on project development, interactions with civil society, participation at seminars, public meetings, networks, e-conferences and international forums.

Selection of research hubs

The following criteria were used for selecting research hubs to be included in the first phase of the program: 1) dynamic large and dense urban landscapes with > 1 million inhabitants, diverse human population, 2) cities with global significance, 3) comparability, 4) major vulnerabilities identified, including effects of climate change, 5) management of diversity and ecosystems a critical and visible issue, 6) recognized need for new governance methods and flexible institutions, 7) high quality research capacity that enable quality control, and provide measurable standards for monitoring progress and assessment of outcomes, 8) established contacts with research groups having experience of working with the research framework outlined above.

Seven cities were selected spanning continents from North America to Europe, Africa and Asia (see fig. 4.4).

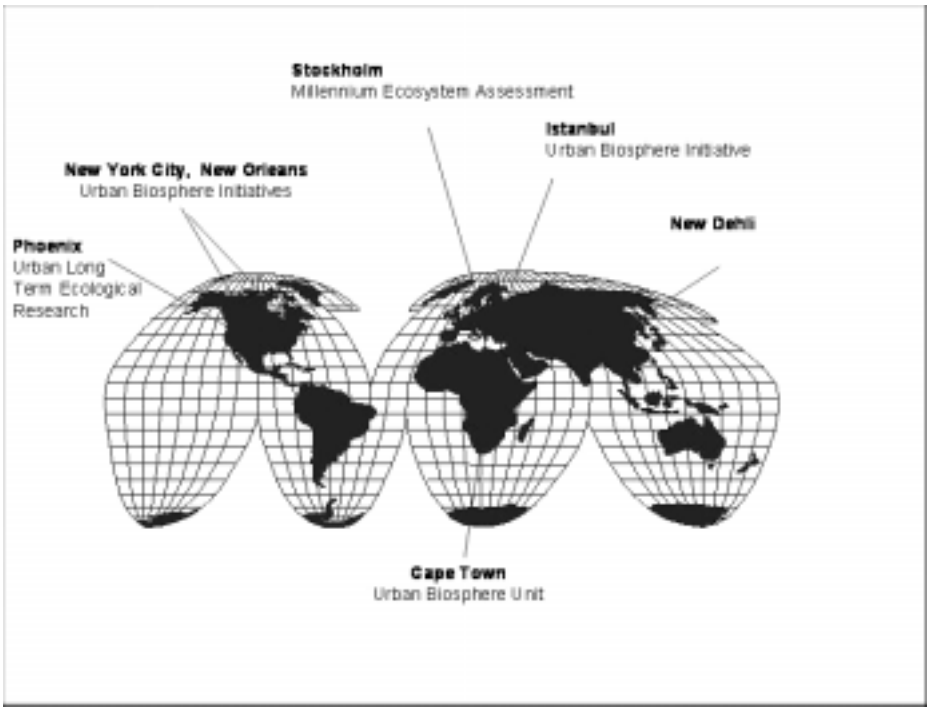


Fig 4.4. The seven selected research hubs to be included in the first phase of the program

Cape Town

The Cape Town region in South Africa is faced with multiple challenges where fragile ecosystems of global importance are under increasing human pressure. Massive inward migration, poverty, and associated health risks, unemployment, water scarcity and lack of equity in access to natural resources represent tremendous challenges. Cape Town has adopted several innovative governance strategies in order to address these issues. The municipality, scientists and community leaders are working together to find solutions that allow for a sustainable management of the unique biodiversity while providing employment, housing and health services to the local population.. Coordinator and contact: The CUBES Cape Town Urban Biosphere Unit , Ruida Stanvliet/Sue Parnell, University of Cape Town; George Davis, SANBI, NormaIndia Mfeketo, Executive Mayor, City of Cape Town

Istanbul

Istanbul Province is the most densely populated area of Turkey with over 10 million people today. The Omerli Water Basin, located on the Asian-Side of Istanbul, supplies almost 35% of the drinking water for Istanbul. Yet, having faced the highest urbanization pressure of all water basins it has suffered irreversible damages to biological diversity in an area with the last and largest heathlands of the Eastern Mediterranean region. The current focus is to reconcile the issues of water management and biodiversity protection with urban development by applying UNESCO's biosphere reserve concept and UNESCO-CUBES Methodology in Istanbul with the possibility of potential "urban biosphere reserve(s)". Coordinator and contact: Dr. Azime Tezer Kemer, Assistant Professor of planning at Istanbul Technical University

New Delhi

New Delhi is one of the largest cities in South Asia with a population of over 13 million. Changes in land-use patterns have taken place progressively in Delhi. A large part of projected development will occur along the Yamuna river bed and conversion of former wetlands, and marshy areas. However, the last few years have witnessed recognition of the problems and a move towards eco-friendly development, e.g. maintenance of green spaces and water bodies in the city's master-plan, and extensive spread of roof-top water-harvesting. There is and increased involvement of

local groups in governance through " bhagedari" of resident welfare associations introduced by the local city government. These developments provide reason to expect that a "leap-frogging" into eco-friendly modes of living and working are within the reach of this large metropolis, located in one of the most populous countries of the world. Coordinator and contact: Director Kanchan Chopra, Institute of Economic Growth, University of Delhi Enclave, Delhi

New Orleans
The citywide flooding following Hurricane Katrina represents the most recent catastrophe in the City of New Orleans. With more than 80% of the city inundated, thousands of people killed or injured and a vast inventory of both tangible and intangible natural and built treasures, on multiple scales, destroyed, crippled, or dispersed. The physical damage and the human misery that succeeded Hurricane Katrina have resonated as a national disaster that had international impacts. The proposed New Orleans Knowledge Network will provide a public forum and a "knowledge network" for resilience and reinvention of the City of New Orleans through research and education that promotes revitalization of the environmental, cultural, and economic values, heritage, and infrastructures in the city. Coordinator and contact: Douglas Meffert, Eugenie Schwartz Professor of River & Coastal Studies, Tulane University

New York
As one of the first megacities, New York City is a living laboratory for the interaction between humans and nature. The CUBES Urban Biosphere Group in New York has conducted research to assess the dimensions of biodiversity-urban society interactions and to explore pathways to reconciling dysfunctional interactions. The concept of Biosphere reserve was found to offer reconciliation of the built environment with biodiversity by motivating and legitimizing current efforts and serving as a sustainability experiment. In the next phase, research will be expanded to look at the role of urban biodiversity in the New York Metropolitan region in securing quality of life and health for the community as well as reducing vulnerabilities to climate change. Coordinator and contact: Urban Biosphere Group: Roberta Balstad, Director CIESIN at Columbia University, Bill Solecki, Professor, Hunter College, Steve Clemants, Brooklyn Botanic Garden

Phoenix
Phoenix is the fastest growing of the large North American cities. The presence of the Central Arizona-Phoenix Long Term Ecological Research project has led to an ever increasing database on urban growth and its socio-ecological dynamics. A large interdisciplinary team are analyzing the driving forces and feedbacks involved with rapid urbanization as well as it effects on ecosystem services. Phoenix is located in a seriously water-limited environment and management of water allocation and the development of decision support tools for water managers and policymakers are the foci of the Decision Center for a Desert City at the Global Institute of Sustainability (GIOS) at Arizona State University. Issues of sustainable water use, food security, and urban growth are at the heart of a new collaborative effort between scientists from the Stockholm Environmental Institute and GIOS. Coordinators and contacts: Charles L. Redman, Director of the Global Institute of Sustainability and Ann P. Kinzig, School of Life Sciences, Arizona State University.

Stockholm
Stockholm is the now largest city in Scandinavia and has been the focus of one of few urban assessments within the Millennium Ecosystem Assessment (www.maweb.org). The assessment, which is still ongoing, has the following objectives 1) provide scientific information on biodiversity patterns and ecosystem services 2) mapping institutional configurations and interplay between actors and institutions involved in management of ecosystem services, 3) identify strategies for strengthening the social-ecological resilience of Stockholm Metropolitan Area (Elmqvist et al. 2004, Barthel et al. 2005). Coordinators and contacts: The studies are conducted by a research group at Stockholm University lead by Prof. Thomas Elmqvist, Dept. Systems Ecology.

4.4.2 Governing freshwater management for food and ecosystem services

The Mission

Together with research, policy and management partners around the world, we will lead the international advancement of a new paradigm for sustainable governance of freshwater management that incorporates the dynamic inter-relations between water, humans and ecosystems. Our focus is to analyse the inter-linkages among freshwater for food production, ecosystem services and other societal water demands, with a focus on (i) governance and management strategies to balance water consumption in interlinked social-ecological systems, (ii) the role of freshwater to maintain and build resilience of agricultural landscapes, and (iii) the need for changes in governance of freshwater for more resilient social-ecological systems.

The Challenge

Freshwater is closely linked to all aspects of human life-support, through its key role in processes that generate ecosystem services and human well-being (Falkenmark & Rockström 2004). It is fundamental for socio-economic development, since it supports food production in agriculture, economic sectors such as forestry and energy generation, and water supply to industry and domestic purposes (UN 1997). Despite the close inter-dependencies between water and development, and despite the well founded concern over an emerging global water crisis, current water governance is not sustainable. Internationally recognised science over the past decade point at the inability of breaking the narrow sectoral approach to water, despite substantial efforts of developing integrated social-ecological approaches to governance and management[1] .

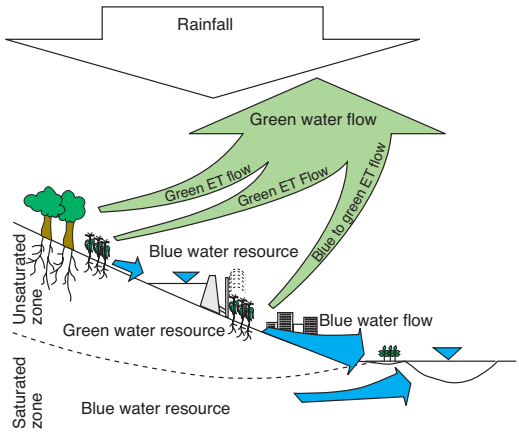
Agriculture is the most extensive social-ecological system on Earth (Millennium Ecosystem Assessment 2005). It has transformed landscapes in all biomes, constituted the engine to economic growth and life-support in most countries (World Bank 2005), while causing major erosion of ecological functions due to resource exploitation (Millennium Ecosystem Assessment 2005). Furthermore, food production is by far the world's largest water consuming human economic activity (Rockström 2003). One of the main challenges of the 21st century is how to meet the water requirements of food production for a growing world population while meeting the increasing pressure on water for other sectors in society, including water needs to secure ecosystem services, and to meet growing demands of cities (Falkenmark & Rockström 2004, Postel 1998, Molden & de Fraiture 2004, UN 2003).

There is a growing concern that freshwater scarcity in agriculture may hinder the possibility of achieving the Millennium Development Goals (MDG) on food and poverty, particularly on sustainable grounds (SEI 2005). Moreover, our recent research has highlighted the worrying correlation between the most poverty and hunger stricken countries (the MDG hot-spot countries) and water-related constraints, showing that semi-arid and dry sub-humid savannah regions of the world emerge as a global hot-spot in terms of freshwater, food and sustainability (SEI 2005), which has resulted in a call for a new triply-green revolution (Falkenmark & Rockström, 2004, Falkenmark & Rockström in prep for PNAS), where increased intensification goes hand in hand with sustaining other ecosystem services (Pretty et al 2005). Global change puts an additional weight on this challenge, through shifts in rainfall patterns, temperatures and frequency of climate shocks.

In response to these pressures we have advanced a new paradigm for water governance (Falkenmark & Rockström 2004) (Box 1), and developed conceptual tools for understanding human dependence on freshwater for terrestrial ecosystem services (Jansson et al. 1998, Falkenmark et al. 2000, Rockström et al. 1999), and the impacts of environmental change on green water flows at local (Rockström et al., 1998, Barron 2004), continental (Gordon et al. 2003) and global scale (Gordon et al. 2005). We have also analysed complex links between water scarcity induced trade-offs between water for food and other ecosystem services (Gordon 2003, Falkenmark & Folke 2003, Falkenmark & Rockström 2004). For example, we recently showed that an additional 2200 km^3/yr more water will have to be allocated for agriculture, under current water productivity levels, in

order to achieve the MDG target 2015 of halving the proportion of malnourished in the world. This corresponds to more than the current global consumption of water in irrigation (1800 km^3/yr), and thus points at the need to prepare for substantial trade-offs with other social (e.g., downstream drinking water supply) and ecological (e.g., fish habitats and biodiversity) demands for water, and for massive investments in policies, and institutional capacities to deal with the upcoming complexity of trade-offs around water resources. One of the least known areas is how to deal with such trade-offs in complex social-ecological systems experiencing non-linear behavior and threshold effects, and hardly any research has so far been done on regime shifts in agricultural landscapes in relation to changes in water flows

Box 1. *Introducing a new paradigm for sustainable water governance*



Use Domain \ Water Flow Domain	GREEN	BLUE
DIRECT	ECONOMIC BIOMASS GROWTH Rainfed food, timber, fibres, fuelwood, pastures, etc.	ECONOMIC USE IN SOCIETY Domestic uses, irrigation, industry and service
INDIRECT	ECOSYSTEM BIOMASS GROWTH Plants and trees in wetlands, grasslands, forests and other biotopes Biodiversity, resilience	ECOSYSTEM FUNCTIONS Aquatic freshwater habitats Biodiversity, Resilience

A new paradigm for sustainable freshwater governance, shifting the focus from planning and management of runoff water flows in groundwater, lakes and rivers (so-called blue water flows) to an integrated approach including rainfall infiltrated in the soil, generating soil moisture on its way to evaporate in support of terrestrial biomass production (so-called green water flow) (Falkenmark and Rockström, 2006). From a policy and governance perspective water remains governed within the Direct-Blue domain, reflected in the latest global freshwater assessment (UN, 1997). We carried out the first global analysis of green and blue water flows to sustain both direct and indirect green and blue functions in social-ecological systems (Rockström et al., 1999).

The focus of Integrated water resource management (IWRM), the agreed framework for water resource management endorsed by the governments in the world at the UN WSSD Summit in Johannesburg 2002, remains on governing and managing blue water resources for economic sectors of society (Direct Blue use in conceptual framework box above). Increasingly environmental water flows in aquatic systems (rivers, lakes, wetlands, estuaries) are included in the IWRM framework (Indirect Blue). A new integrated governance paradigm will include direct green support to terrestrial ecosystem functions including economic biomass growth. This is a necessary governance step towards the inclusion of cross-scale interactions and feedbacks between freshwater and dynamic social-ecological systems.

Research Questions

The proposed research will require a strong transdisciplinary approach, linking social sciences (particularly on institutions, adaptive capacity, policy integration, economics, and rural development) and natural sciences (particularly on agronomy, hydrology, soil science, climatology and ecology), and advancing inter-disciplinary science on resilience and vulnerability, environmental policy integration and governance.

1. *What is the role of green and blue water flows in sustaining linked social-ecological systems, particularly in terms of dynamic feedbacks and trade-offs between water for food production and other terrestrial and aquatic ecosystem services needed for societal development?*

   Research and policy on freshwater governance and management has approached water as a static commodity that can be redistributed for societal purposes. It has centered on how human activities change the flow of blue water (Box 1) across the continents through water withdrawals and dams (Dynesius & Nilsson 1994, Vörösmarty et al. 1997, Rosenberg et al. 2000), including effects on aquatic ecosystems (Smakhin et al. 2004), and mechanisms for allocation, dealing with trade-offs, and managing conflict resolution of accessible blue runoff resources. We have shown that this is a narrow approach to water resource functions in dynamic and linked social-ecological systems. It misses some of the largest forces driving changes in the hydrological cycle (e.g., productivity change in rainfed agriculture) and does not offer integrated knowledge to cope with future freshwater driven reductions in social-ecological resilience (Gordon 2003, Folke 2003, Falkenmark & Folke 2003) in the current era of rapid global change (Steffen et al. 2004). We have therefore focused on managing water starting with precipitation, integrating blue water management and particularly the role of green water (i.e. the water flow from land to the atmosphere, see box 1) for agriculture and ecosystem services (Rockström et al. 1999, Rockström & Gordon 2001, Falkenmark & Rockström 2004, Jansson et al. 1998) and socio-ecological resilience (Folke 2003, Gordon 2003), and how this links to governance (SEI and SIWI 2006) and management (Rockström 2003).

   In future research we will advance theories and methods for the analysis of freshwater and the generation of ecosystem services, and water trade-offs across scales between water for food and ecosystem services. Particular focus will be on developing and refining tools and methodologies to estimate water requirements of green water flows to sustain ecosystem services incorporating non-linear systems behaviour in relation to trade-offs. For example, we have just initiated a new project collaborating with Hal Mooney, Stanford University, Don Peden, ILRI, and scientists at FAO on doing this for livestock systems in the world.

2. *How does freshwater management alter the resilience of social-ecological systems, and what are the management options to cope with social and environmental drivers of change, feedbacks and the risk of regime shifts?*

   Trade-offs between water for food and other ecosystem services are further complicated by the existence of catastrophic regime shifts. The way humans manage land and water (e.g., in irrigation systems, forestry and rainfed agriculture) may result in erosion of social-ecological resilience, and the crossing of thresholds causing fundamental changes in ecosystem feedbacks resulting in rapid loss of bundles of ecosystem services and thereby livelihood opportunities of people who depend on these (Comprehensive Assessment, in prep). We have previously shown that the existence of multiple stability domains and thresholds in (Scheffer et al. 2001) poses new and fundamental pressure on governance for ecosystem management (Folke et al. 2005, Olsson et al. 2004). However, surprisingly little is known on are central to strategies for adaptation. Our research will directly contribute to the ongoing development and implementation of national adaptation plans of action (NAPA) within the framework of the UN framework convention on climate change (UNFCCC), through and vulnerability analyses (Downing 2002).

   The existence of regime shifts in social-ecological systems poses fundamental challenges for governance and management. Internalising the risks of water-induced regime shifts of agricultural systems remains a fundamental gap hindering sustainable water governance. The research within this theme will advance our understanding of the slow variables underlying erosion of resilience, and introduce theories and methods on how to analyse the risk of water induced regime shifts in agricultural landscapes.

This research will include applied field research in particularly sub-Saharan Africa and South-east Asia, on management strategies at the local catchment level and on options to build water related resilience in agricultural social-ecological systems. A particular focus here will be to link our own research with research by, e.g., Pretty & Hine (2001), on win-win strategies to simultaneously raise agricultural productivity, improve water efficiency and build social and ecological resilience.

3. *How can water governance incorporate management of green water flows in order to include the drivers and incentives to sustain long-term social and ecological resilience?*

At the WSSD in Johannesburg 2002, countries of the world agreed to adopt principles of Integrated Water Resource Management (IWRM), and to develop and implement national IWRM plans. This is an important advancement of water governance, but is still narrowly implemented, as it remains based on a static blue water focus.

n this research we will advance approaches and methods for governance and management that incorporates dynamic green and blue water functions and feedbacks. Freshwater feedbacks occur across scales, with upstream-downstream implications from management at the local community and catchment level to the meso-scale at the river basin level. At the same time, anthropogenic impacts on land and water resources, cause feedbacks in terms of changes in rainfall patterns. Governance and management of freshwater requires under standing of water demands, requirements and consumption, across the continuum from the local to the global scale, taking the dynamics of the hydrological cycle into consideration.

This research will be carried out particularly in context of the Millennium Development Goals, and build on the new initiative on sustainable water governance between SEI and SIWI (the Green and Blue Initiative). We hope to link our own research on a triply-green revolution (Falkenmark & Rockström, 2004) to the research of Djurfeldt et al. (2005), who for the African context point out that a green revolution is not only necessary but also possible in sub-Saharan Africa, if good governance and adaptive management is in place.

4. *What are the implications for international water policy and governance of growing human pressures on finite freshwater resources, the need to secure water for ecosystem services, and drivers of change related to trade, security, and globalisation?*

The complex challenges related to water governance for food production are closely linked to agricultural policies at the regional and global scale. Water scarcity already at present drives an estimated 25% of global food trade (Postel 1998), and as pointed out by Allan (1995), virtual water (water consumed to produce traded food) plays an important role to release pressure on scarce local water resources. Political priorities are often geared at national food security. A truly inter-disciplinary research approach is required, linking social, political and natural sciences, in order to address the full scale of options from local and regional water governance, and trade in a globalising world. We will link the research on freshwater in social-ecological systems to support human wellbeing, particularly in the context of the MDG process, with social processes at the regional transboundary scale and the global scale, related to transboundary water sharing, the WTO and global trade, security and global change. This research will furthermore be linked to historical analyses and future scenarios of social-ecological water futures. This will be done through collaboration with the International Institute for Sustainability under Professor C. Redman integrating historical studies of water related rise and fall of civilisations, and future oriented scenario research using the SEI and Tellus PoleStar and WEAP platforms.

Research Process – research hubs addressing different scales

An important element of the research is to carry out integrated systems research across temporal and spatial scales, including social and ecological feedbacks. The research will build on ongoing

research work, particularly in Sub-Saharan Africa and South-east Asia
We will carry out the research at different scales, with a strong emphasis on cross-scale synthesis contributing to theory building on the role of water and agriculture in socio-ecological resilience.

1) At the local scale the research questions examine how innovations in small-scale agriculture influence the resilience of smallholder farming communities in the semi arid and dry sub-humid tropics (focusing on sub-Saharan Africa), and policy and institutional requirements to achieve adoption and adaptation of innovations and adaptive co-management of natural resources.

   This research will benefit from several ongoing research projects. In Southern Africa, the research will build on a program called "Small-scale system innovations in integrated watershed management (SSI)", which focuses on two river basins (the Thukela River Basin, South Africa and the Pangani river basin, Tanzania). The SSI programme links land and water management across scales, from field to basin, with a focus on resilience building in rainfed farming systems. The proposed Mistra research will add novel research on adoption and adaptation of local social-ecological farming systems, human agency and social institutions in support of improved management. We will also develop research on freshwater management for resilience linked to our research programme on sustainable sanitation (www.ecosanres.org), in Latin America, Africa, South Asia, and China.

2) At the landscape/drainage basin scale we will address issues on how to integrate green water management and resilience thinking into Integrated Water Resources Management, i.e., research on a new paradigm for water governance, and on trade-offs among water for food, other ecosystem services, and direct societal uses.

   This research will build on several ongoing research projects around the world (in Europe, the US, the Middle East, Latin America, sub-Saharan Africa, India, the Mekong and China). Together with partner organisations, SEI has developed a modelling platform for integrated water governance, management and planning, called WEAP (Water Evaluation and Assess ment Planning Tool, www.sei.se or www.weap21.org). WEAP is today applied in over 70 river basin project around the world, with the focus on supporting regional institutions (catchment management agencies, river basin organisations, ministries for water, agriculture and environment) on integrated water resource management (IWRM). This work is furthermore closely linked to several projects of the CGIAR (Consultative Group on International Agricultural Research) led Challenge Programme on Water for Food (CPWF), particularly in the Limpopo basin (Botswana, Zimbabwe, South Africa, Mozambique), the Volta (Ghana and Burkina Faso), the Sao Fransisco (Brazil), and the Mekong basin (China, Lao, Cambodja, Vietnam, Thailand). Recently, SEI together with SIWI developed the Green and Blue water Initiative (GBI) (mentioned above), which will focus on the Kagera basin in central Africa (Rwanda, Burundi, Tanzania, Uganda) and the Mekong basin.
   The Mistra research will, together with partners and stakeholder around the world, advance this substantial body of ongoing research, with the objective of developing the next generation of integrated knowledge and governance on sustainable water management.

3) At the global scale we quantify green water flows for ecosystem services and address the vulnerability of the Earth System to alterations in green water flows, as a support to global policy processes on water and development

   The Mistra Institute will enable us to advance this pioneering research, linking it to global change feedbacks on hydrology, and the policy and governance implications of water trade-offs related to trade (of food, timber products etc.), ecosystems (e.g., effects on biodiversity) and management (e.g., agriculture and forest policies). The research will be carried out in close collaboration with partners engaged in a recent research and governance program initiative on sustainable water management – the Green and Blue Initiative (GBI), led by SEI

and SIWI (SEI and SIWI, 2006) with partners from research (IWMI, IFPRI, IUCN, ASARECA, Unesco-IHE, and others) and policy (GWP, WB, WWC, IFAD, and others).

4) Cross scale analysis and synthesis aimed at integrating research and to contribute to developing theories of cross-scale resilience across landscapes and sectors exhibiting multiple interacting regimes. We will address feedbacks of how local and regional agricultural change may alter the Earth System, and how changes in the Earth System can affect the vulnerability of local small-scale farmers, in particular in relation to impacts of and adaptation to climate change. In policy terms, cross-scale analysis and synthesis will provide the basis for generic directions and practical guidelines on sustainable water governance and management, across scales, from local catchments to the global freshwater agenda.

The Mistra Institute will enable us to have a higher focus on integration across research themes and to put more efforts into integration and synthesis of ongoing research. This will in particularly be linked to the ongoing process of initiating a research program on water and resilience in agricultural landscapes together with partners in Resilience Alliance.

The research plan 2007-2009

The three research questions addressed at various scales will frame the science on freshwater governance within the Mistra Institute during the build-up phase. We will develop the Mistra research from existing research partnerships and ongoing research projects. This will generate a new inter-disciplinary set of research activities, which will range from local field research, to regional and global analyses. The initial phase will be evaluated and form the basis for the gradual growth and direction of the research.

We will start by carrying out applied research in a few selected river basins in the world, chosen among the basin where we currently have close institutional collaboration, including basins in Latin America (the San Fransisco), sub-Saharan Africa (the Volta, the Nile, the Limpopo, the Pangani, and the Thukela), Middle East (the Jordan), South-east Asia (the Mekong) and in China (the Hai and Yellow river). During the course of the growth of the Mistra institute programmatic initiatives will be developed, and possibly the number of focal basins increased.

The research will be carried out in close partnership with local institutions, and we envisage a series of stakeholder workshops to focus current research in relation to the outlined questions, and to develop new research. The Mistra Institute may take the initiative to develop a research network on sustainable freshwater governance, working closely with key institutions in the field (such as the CGIAR institutions, the Global Water Partnership, SIWI and others). The Resilience Alliance constitute an important partner network, where we at present are in the process of advancing a research initiative on water, food and resilience together with strong research institutions around the world (including the Global Sustainability Institute with Charles Redman and Joseph Tainter, Brian Walker at CSIRO in Australia, and Steve Carpenter at University of Wisconsin).

The freshwater research of the Mistra Institute will already at the build-up phase be closely linked to water policy processes. The Institute will collaborate with SIWI on bridging science to policy on sustainable freshwater governance. The Institute will be prominently represented at the World Water Weeks in Stockholm, interact closely with the World Water Council (WWC), and contribute to wider policy work such as the World Water Assessment Programme of the UN (WWAP), the World Water Forum (WWF), and the follow-up of the Comprehensive Assessment of Water management in agriculture (CA).

4.4.3 Governance and ecosystem management of coastal and marine systems

The mission

The overall goal of coastal and marine ecosystem management is to secure the ability of oceans to

provide ecosystem services for societal development. While there have been some local successes, current management of marine social-ecological systems has undeniably failed to achieve this goal at a regional or global scale. We argue that responding to the global marine crisis requires new approaches that focus on supporting and sustaining ecosystem resilience. Such approaches contest current management and metrics and stress the significance of multilevel adaptive governance systems for marine and aquaculture management. Such governance systems need features that can deal with cross-scale socioeconomic drivers of globalization that cause coastal and marine vulnerability. We will collaborate with leading researchers and contribute to the development of insights, policies and systems of adaptive governance of coastal and marine ecosystem services in temperate and tropical regions, including the Baltic Sea drainage basin.

The challenge

Marine environments worldwide are in serious decline due primarily to over-harvesting, pollution, disease and climate change. In many locations around the world, human-made stresses to marine ecosystems have exceeded their regenerative capacity, causing dramatic shifts in species composition and ecosystem states that result in severe economic and social costs (Bellwood et al. 2004, Steele 2004). Anticipating and preventing unwanted regime shifts (or, conversely, promoting desirable ones) will require improved understanding of the complex dynamics and processes that support or undermine resilience and of the socio-economic drivers and governance systems that shape the use of living marine resources and services (Hughes et al. 2005).

It is increasingly recognized that current management structures, individual fishing rights policies and single-species theories of fish populations fail to match human activity to ecological structure and function (Wilson 2006). Fisheries management is going through a paradigm shift from single-species models and maximum sustainable yield measures to the ecosystem approach, including the role of biodiversity in ecosystem functioning (Pitcher 2001). Social science has made progress in coastal and marine research and policy on common pool marine resources, particularly in relation to local property rights, with important lessons for institutional design, selforganization and governance at multiple scales. It is now time to link and further develop such insights to interpret complex marine ecosystem dynamics and the implications of possible regime shifts into management practice and economic policy. The proposed research will focus on

- Understanding marine resilience through a focus on (i) spatial dynamics (ii) cross-scale effects, timelags and feedbacks, and (iii) identifying and analysing important functional groups of organisms that contribute to marine resilience.
- Resilience in marine social-ecological dynamics by exploring new ways to incorporate incentives across scales that prevent overexploitation of marine resources and addressing multi-level governance systems of fisheries and aquaculture.

The research questions

1.What are the spatial processes that sustain marine resilience and their historical context?

Marine reserves are often too small and too far apart to sustain essential ecological processes within the broader seascape (Nyström & Folke 2001). Better appreciation of non-equilibrial dynamics and multi-scale processes of marine ecosystems is required (Bellwood et al. 2004). The history of ecosystems (how they got to be in their current condition) illuminates the cumulative and interactive effects of sequences of human and natural events that have shaped coastal and marine ecosystems (Jackson et al. 2001). We intend to analyze the broader temporal and spatial ecosystem perspective in relation to periods of rapid change and reorganization and sources and sinks of resilience to generate understanding for management in order to secure coastal and marine ecosystem services.

2. In what way does loss of functional biodiversity lead to undesirable regime shifts?

The simplification of food webs and loss of biodiversity are eroding the resilience of marine ecosystems and increasing their vulnerability to environmental change (Worm et al. 2006). Overfishing of herbivorous fishes has contributed to algal blooms on reefs because algae released

from their consumers out-compete corals for space. Consequently, overfished reefs are less resilient to recurrent disturbances such as hurricanes and more vulnerable to coral bleaching and mortality caused by global warming and may shift into undesired states (Nyström et al. 2000). An emerging approach highlights the importance of key processes undertaken by critical functional groups (i.e. collections of species that perform a similar function, irrespective of their taxonomic affinities), shifting focus from conservation of targeted (often, commercially important) species to active management of functional groups that support essential processes and sustain ecosystem services (Folke et al. 2004). We intend to develop new metrics that are process oriented and that account for the role of functional groups in ecosystem dynamics to help improve stewardship of marine resilience.

3. How can aquaculture development be reconciled with ecosystem based management?
Aquaculture has often been put forward as the solution to overexploited marine ecosystems, but it still depends on substantial marine ecosystem support in terms of e.g. fishmeal (Folke & Kautsky 1989, Naylor et al. 2000). The challenge is to develop environmentally sustainable and socially viable aquaculture that recognizes its embeddeness in coastal and marine social-ecological systems. New technologies have created greater mobility of fishing fleets in combination with the information technology that helps fast distribution of e.g. fishmeal on global markets. Feedbacks from ecosystems to aquaculture development are often masked by economic substitutions of resources in space or in time, a substitution that tends to expand globally as illustrated in figure 4.5 of source countries for fishmeal uses in shrimp farming in Thailand.

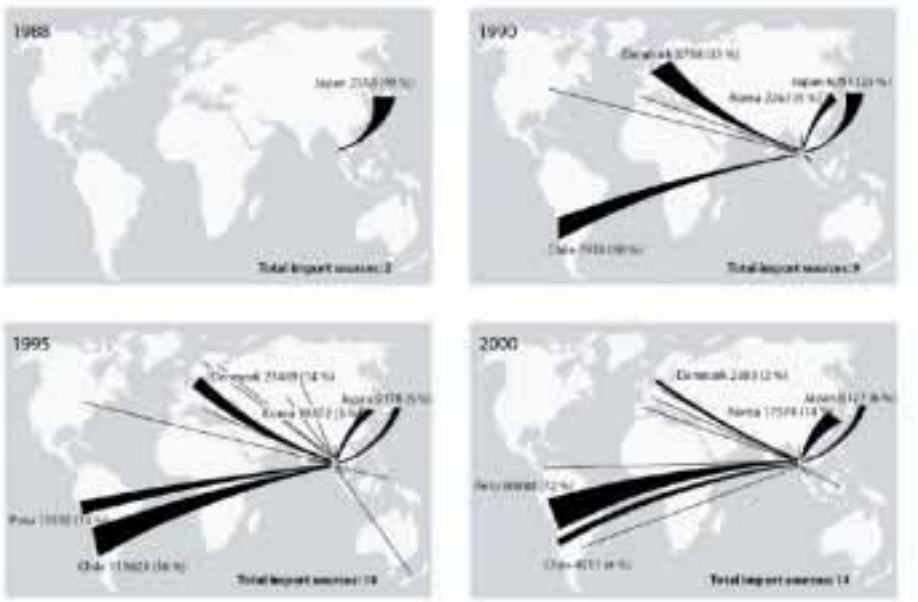


Figure 4.5. Global interconnections of aquaculture and fisheries - the import of fishmeal to Thailand for shrimp aquaculture production (Deutsch et al. in press).

A successful transition of reconciling aquaculture with ecosystem-based management will require institutions better able to economize on the acquisition of feedback about the impact of human activities. This is likely to be achieved by multilevel institutions whose organization mirrors the spatial organization of the ecosystem and whose communications occur through a polycentric network (Wilson 2006). We intend to analyze such issues.

4. In what way do global social drivers impact on marine social-ecological systems?
Until recently, exploitation of marine resources was commonly constrained by the inaccessibility of remote and offshore locations. Such constraints have evaporated with globalization and new markets can develop so rapidly that the speed of resource exploitation often overwhelms the ability of local and regional institutions to respond. Water fleets and mobile traders can operate like 'roving bandits' since global markets often fail to generate the self-interest that arises from

attachment to place. Spatial expansion masks regional depletions, a common characteristic of sequential exploitation (Berkes et al. 2006), illustrated in Figure 4.6. Can global markets function in the opposite way and under what conditions?

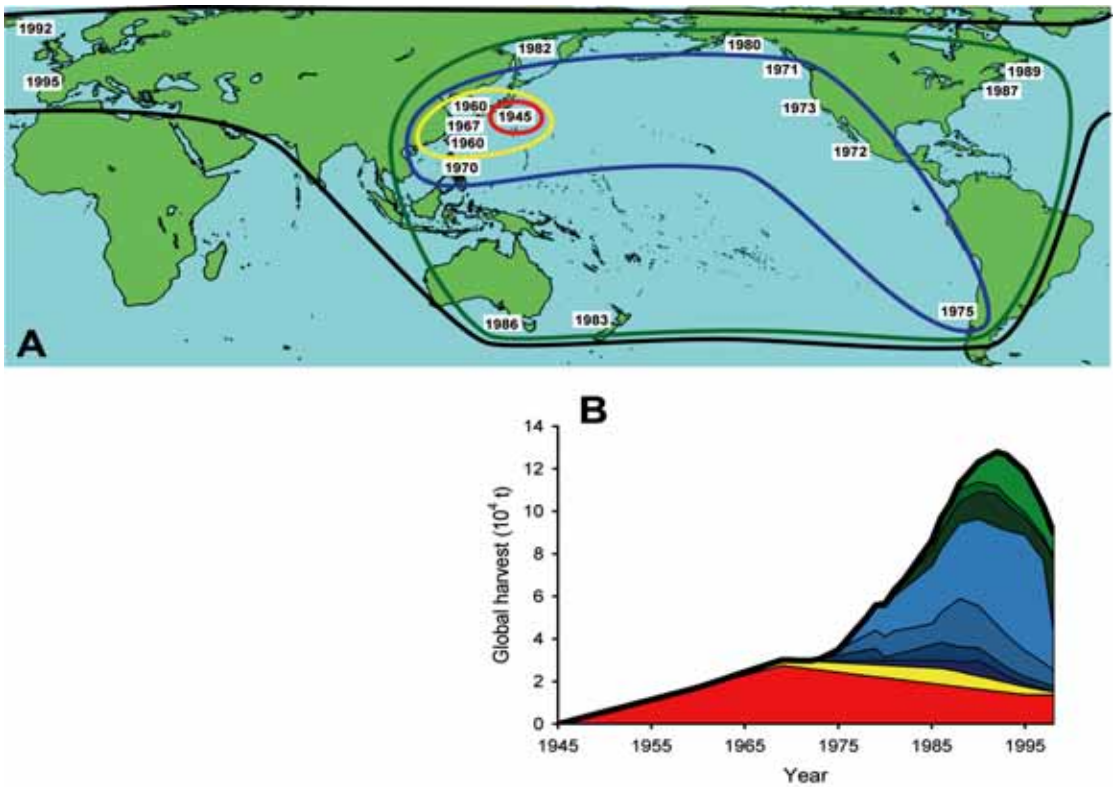


Figure 4.6. Sequential exploitation of a marine resource. A) initiation year by location of major commercial fishery for sea urchin; B) global sea urchin harvest over time by region, in chronological ascending order – Japan, Korea, Washington and Oregon (USA), Baja Mexico, California (USA), Chile, NE Pacific (Alaska and British Columbia), Russia, NW Atlantic (Maine, Nova Scotia, New Brunswick) (from Berkes et al. 2006)

5. What are the features of multilevel governance and selforganization for marine resilience?
A multilevel social/organizational arrangement that is congruent to ecosystem dynamics increases our ability to obtain feedback from the system and reduces the transactions costs of management. But management must go beyond learning-by-doing locally and develop the ability to learn from mistakes or progress made elsewhere, and must do so at multiple levels of governance, from local to international. What are the role of e.g. actors groups, institutional entrepreneurs, social networks, social memory, adaptive co-management processes in this context. National and international levels have critical roles to play in instituting property rights; making local controls work by strengthening local monitoring and enforcement capabilities; and tracking ecological change and international trade. The research will address the organizational structures, and multilevel institutional arrangements including systems of adaptive governance.

The research process
We aim at taking the social-ecological resilience of coastal and marine systems several steps forward through analyses of social and economic drivers and globalization on marine resource exploitation and sustainability, including aquaculture development, and investigate options for adaptive governance of social-ecological systems. In our previous work on regime shifts and resilience we have focused on coral reefs, functional roles of species and their management (Nyström et al. 2000, Hughes et al. 2003, Bellwood et al. 2004). We have started to extend our focus to social-ecological systems incorporating coastal and marine systems in both tropical and temperate areas (Adger et al. 2005, Hughes et al. 2005) including the Baltic Sea (Österblom et al. in review). We have initiated analyses of social and economic drivers and globalization on marine resource exploitation and resilience (Berkes et al. 2006, Deutsch et al. in press). We have experience in analysing the link between fisheries and aquaculture (Naylor et al. 2000) and have started to address aquaculture development from a complex systems perspective (Folke 2003).

The research plan 2007-2009
Based on our work on adaptive governance and social-ecological systems (Olsson et al. 2004, Folke et al. 2005) we have been invited to work with Prof. Terry Hughes and his group at James Cook University in Townsville, Australia on the social transformation and emergence of the new governance system for the Great Barrier Reef and are deeply involved in collaborative work with the Australian Research Council's (ARC) Centre of Excellence for Coral Reef Studies on social-ecological resilience; a project that has the potential to take off considerably under a SMI and develop into several new front-areas in the coming years.

Dr. Rosamond Naylor is spearheading a new program at Stanford University on Food Security and the Environment (FSE) that will address global hunger issues and environmental problems related to intensive food production, including aquaculture. The program is building on the research of 15 professors from a wide variety of disciplines at Stanford including economics, political science, hydrology, medicine, and ecology. We have a productive record of collaboration and now there are options for collaboration in the areas of intensive aquaculture and livestock production.

The marine resilience group of the Resilience Alliance has an explicit focus on social-ecological resilience with an amazing track record of high-visible publications. The group is run by Terry Hughes and Carl Folke with plans to continue to explore unknown territory for new insights into social-ecological systems dynamics and policy. There is also collaboration with an NCEAS working group in the pipeline headed by Boris Worm and Enric Sala on biodiversity in marine ecosystem services and the economic implications.

We plan to be part of the co-management experiments in relation to fisheries in Sweden and also intend to initiate studies on social-ecological systems in the Baltic Sea drainage basin in the context of regime shifts, biodiversity and resilience. There is a long tradition of high quality marine work at Stockholm University and in particular at Dept. of Systems Ecology. CTM has been approached by MARE (the marine eutrophication project of Mistra) about the interest for hosting the new phase of the programme. MARE has developed a user-friendly decision support system (Nest) for cost-effective measures against eutrophication of the Baltic Sea and main target groups have been decision-makers within the Helsinki Commission (HELCOM), as well as actors in the Baltic Sea States working with the implementation of the EU Water Framework Directive. MARE is now interested to take a step into the direction of social-ecological systems and governance issues. There is also potential for further collaboration with Björn Carlsson's Foundation for the Balitc Sea through Karl-Göran Mäler's and the Royal Swedish Academy of Sciences' engagement.

There is also a large potential in expanding our collaboration on coastal ecosystems and coastal social-ecological systems with the Western Indian Ocean Marine Science Organization (WIOMSA) and its Marine Science for Management (MASMA) Programme with field work, participatory and adaptive co-management processes.

4.4.4 Adaptive governance of dynamic landscapes

The mission
The Millennium Ecosystem Assessment recently emphasized the role biodiversity may have as insurance mechanisms to maintain resilient ecosystems and a sustainable flow of ecosystem goods and services to society. We argue that sustaining this flow of ecosystem services requires a paradigm shift where current strategies of species conservation in static reserves is complemented with a strategy that maintains response diversity in the larger landscape. Such a strategy calls for innovative tools such as dynamic reserves, as well as new flexible governance and management arrangements. We will mobilize world leading research groups, policy makers and practitioners in a joint effort to explore and analyze these new approaches for advancing our understanding of social-ecological resilience in temperate and tropical human-dominated managed landscapes.

The challenge

The classical view of a single equilibrium in nature has been reflected in, for example, rules such as fixed sustainable yields and popular notions such as the balance of nature. As we have emphasized in the introduction, this view is gradually replaced by a view of ecosystems as complex, adaptive systems, characterized by historical dependency, non-linear dynamics, and multiple basins of attraction (e.g. Levin 1998). In this context, and in a world that is increasingly impacted by human activities, biodiversity and components thereof become essential to maintain resilient ecosystems and ensure a sustainable flow of ecosystem goods and services to society (MA 2005, Kremen & Ostfeld 2005), particularly in the face of uncertainty and change (Folke et al. 2004). Although we are still far from understanding the components of ecosystem resilience, Elmqvist et al. (2003) proposed that one critical and measurable component is the so called response diversity defined as the diversity of responses to environmental change among species contributing to the same ecosystem function (Elmqvist et al. 2003). In other words, when many species occur within a single functional group (e.g. pollinators), the risk of the specific ecosystem function (e.g. pollination) being entirely lost from the landscape is reduced (Fischer et al. 2006). However, response diversity is mainly sustained by spatio-temporal variation at the landscape level and is thus at odds with conservation strategies that emphasize long term continuity and stability.

These new perspectives of ecosystems and management have important consequences both for the selection of management systems in production landscapes such as forestry and agriculture as well as for the design of protected areas. Firstly, management with the aim of maintaining or enhancing response diversity may, or may not correspond with current strategies for conservation of biodiversity. It seems naive to believe that response diversity can be maintained by strict conservation alone. Secondly, the idea of using protected areas to "freeze" parts of a landscape for "eternity" is highly unrealistic and problematic (Bengtsson et al. 2003). Many protected areas need not, and should not, be static entities, but instead be part of large-scale dynamic and adaptive management across the landscape that includes both protection and, if needed, restoration. Conservation strategies must actively incorporate the large areas of productive land in forestry and agriculture, as is advocated in the Unesco Man and Biosphere program (www.unesco.org/mab). We therefore argue that there is a need for a paradigm shift where the current strategy based on conservation of species and static reserves is complemented with a strategy that includes management of response diversity in the production landscape and also includes components such as dynamic reserves (Bengtsson et al. 2003). The latter represents areas with a time-limited protection which over long time periods are spatially mobile in the landscape. Such spatial dynamics may be important as an insurance mechanism that provides a buffer for environmental variation and uncertainty (Fig. 4.7).

Most formal social institutions are today designed to manage static protected areas and there is therefore a need for new innovative and flexible institutions (Elmqvist et al. 2004). Human-free" parks and protected areas were the primary focus of government-run conservation projects until the eighties. Such top-down conservation strategies that exclude local residents have been widely contested due to their negative impacts on the social and economic structures of resident communities.

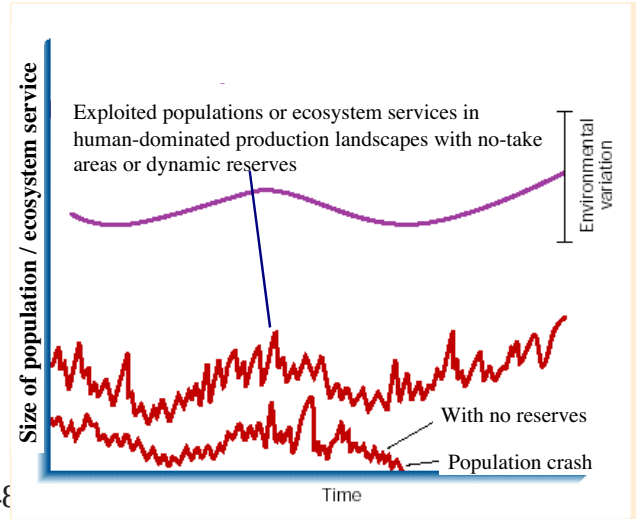


Fig.4.7. The role of dynamic reserves or no-take areas for maintenance of populations or ecosystem services in production landscapes. Modified after Pauly et al. 2002.

In recent years, the limitations of parks and reserves have become even more apparent as they often fail in their conservation goals as well as in meeting the needs of local people. As a result, considerable effort has been placed on designing new approaches including community-based conservation and integrated conservation and development programs. There is also an increasing global recognition of the role of informally protected areas, such as sacred groves, for maintaining ecosystem services in production landscapes (Tengö 2004).
The involvement of local people in the creation and maintenance of dynamic landscapes and management of ecosystem services and response diversity often requires adaptive governance strategies. Co-management is a key component of such governance and may consist of networks of problem-solvers, often involving cross-scale linkages across levels of political organization. Two major factors behind successful co-management seem to be social capital and the presence of social networks for initiating and maintaining collective action (e.g. Ostrom 2005). The concepts of bonding and bridging social capital are becoming increasingly important. Bonding social capital describes the links between people with similar objectives and postulated to enhance the possibility for collective action (cf. Granovetter 1973). Bridging social capital, on the other hand, describes relations ("bridges") between different groups, as a mechanism to enhance innovative capacity through access to distant and diverse knowledge/information and contribute to conflict resolution. Specifically, analyses of the ratio of bonding and bridging social capital are crucial for a deeper understanding of community based management of ecosystem services, biodiversity, protected areas and collective action.

The Research questions:

1. To what extent does management that result in maintaining or enhancing response diversity in ecosystems increase the capacity for renewal and reorganization following disturbance and change? Response diversity is hypothesized to be important in managed landscapes since ecosystems with high response diversity provide a buffer that insures the system against failures resulting from misinformed and misguided management actions and policies. We will develop a framework for analyzing response diversity in different functional groups and explore conditions for how response diversity is generated and maintained at the lands cape scale.

2. To what extent do dynamic reserves represent insurance mechanisms that buffer against surprise and uncertainty and contribute to a sustained production of ecosystem services in agriculture and forestry? We will use landscape modeling to analyze the role of dynamic versus static reserves under different scenarios of environmental change. We will for example include effects of climate change and analyze the effect of static and dynamic reserves on specific ecosystem functions as a result of changes in migration and local extinctions due to changes in temperature and precipitation. We will also analyze how dynamic reserves can be used to tackle issues of landscape connectivity and robustness.

3. To what extent do differences in social network structure and the ratio of bonding and bridging social capital, result in differences in success in management of ecosystem services, protected areas and in collective action? From a network theory perspective, bonding social capital may be quantified as the density of the network and bridging social capital may be quantified using metrics such as betweeness centrality, and degree of isolation of groups. Further, qualitative aspects of networks and their dynamics, such as the role of different actors as leader, communicators and facilitators, and how they emerge, can be assessed by combining the quantitative measure with qualitative approaches.

4. How can governance systems be shaped and stimulated to emerge across spatial and temporal scales in order for management of ecosystem services to better cope with uncertainty, surprise and vulnerability? We will use historical approaches and process tracing to study the development of governance and management arrangements in various social-ecological

systems. We will also conduct comparative analysis of a number of case studies around the world to identify sources of resilience for dealing with uncertainty and change. It will especially focus on adaptive capacity, transformability, learning and innovation in social-ecological systems.

The Research process

With lessons learnt from communities and local institutions (Berkes et al. 2003), we have started to address networks of reserves and their formal rules and informal management in temperate and tropical forests. We have also analyzed the emergence of the adaptive governance system of Kristianstad Wetlands, a recent MAB area (Olsson et al. 2004) and the role of cross-level linkages and social networks in this context, contrasting EU legal frameworks like Nature 2000 and the Water Directive. The proposed research will initially focus on landscapes and how regional resilience of social-ecological systems is influenced by the nature of the reserve networks they contain. We will investigate how adaptive governance systems can enable and enhance ecosystem management. This includes how to manage reserves in dynamic cultural landscapes, based on the experiences gained from biosphere reserves within the Unesco Man and the Biosphere World Network (MAB). The analyses coordinated at SMI will initially be done in close collaboration with NCEAS, Santa Barbara and the Unesco/MAB at HQ, Paris, the Unesco New York Office, the Biosphere Reserve Integrated Monitoring program (BRIM), the Centre for Conservation, Governance and Policy in India (www.atree.org) and the science committee of bioSustainability of Diversitas, (www.bioSustainability.org).

The Research Plan 2007-2009:

Biosphere reserves – experiments in sustainable futures

Biosphere reserves constitute over 440 sites in more than 100 countries and are coordinated in a World network by the UNESCO Man and Biosphere Program (www.unesco.org/mab). Biosphere reserves promote sustainability and provide arenas for developing methods to promote social and economic development based on wise management of ecosystem services. The MAB concept is based on a human-in-nature perspective (UNESCO 2002) and the ecosystem approach for managing ecosystem services, i.e. including natural and cultural values (Bridgewater 2002, UNESCO 2000). It also aims to secure participation in multi-actor processes. It has often been stated that the value of the Biosphere concept lies in its flexibility and the absence of strict boundaries since this leaves ample space for site specific implementations of the concept (Alfsen-Norodom & Lane 2002).

The over 440 MAB areas are located around the globe and range from recently nominated to some established when the MAB-process begun 30 years ago. While existing under the same framework, they vary in sizes, physical conditions, institutional settings, social network structures, and in degree of success in fulfilling their aims. A critical examination of the results of the periodic review of Biosphere reserves and of the Biosphere Reserve Integrated Monitoring program (BRIM) is needed to creatively tap into the wealth of experience and knowledge of the network. The dynamic learning processes embedded in the concept and practiced in various ways in some of the Biosphere reserves can help us understand the functioning and emergence of adaptive governance in social-ecological systems.

We will start with the development of performance criteria and the identification of trends, response variables and indices of changes in response diversity. We will also develop and analyze landscape models under different scenarios of environmental variation. Through the World network we will have direct access to data and field experiences. Potential Biosphere sites to be included in the analyses are: Arganaraie oasis in Morocco, Boucle de Baoule in Mali, Les Cevennes in France, Clayoquot Sound in Canada, Tonle Sap Great Lake in Cambodia, Xishuangbanna in Yunnan, China, Uluru (Ayers Rock-Mount Olga) in Australia as well as Kristianstad Vattenrike Biosphere and others as the project develops. In collaboration with scientists and practitioners from biosphere reserves in France and Sweden we will participate in multi-actor processes, developing and tes-

ting different tools for adaptive co-management. Such processes include for example participatory modeling of social-ecological systems and resilience. These tools are aimed to combine different mental models including attitudes, values, preferences, perceptions, and expectations in monitoring, evaluating, and responding to change in social-ecological systems. Participating in these social networks allow us to transfer scientific knowledge which can be combined with other sources of knowledge to enhance ecosystem management. The purpose is also to conduct comparative analysis between these case studies. These social learning processes can increase our understanding of adaptive governance including social structures and processes for enabling and enhancing ecosystem management.

Recent work conducted in collaboration with the Earth institute at Columbia University (CUBES) has demonstrated that the relevance of the biosphere concept goes beyond the World Network. In fact some of the most dynamic and promising work on the biosphere concept has taken place in ecosystems considered degraded and unworthy of conservation such as arid lands under private ownership, degraded agricultural landscapes and in urban landscapes (Alfsen-Norodom 2002). There will thus be synergies between studies under this theme and the analyses of urban biospheres in the theme on urban social-ecological studies. The comparison between different Biosphere reserves will also be complemented with a comparison with Protected Areas such as National Parks and Nature Reserves, both in temperate and tropical areas, privately owned reserves or under co-management with NGOs, and informally protected areas such as sacred groves.

4.5 Emergent research issues

4.5.1: International relations and social-ecological systems

Implementation of sustainable governance is difficult and should be recognized as such. Actors on all scales are bound up by restraints. Globalization increasingly results in more complex cultural mixtures, new social hierarchies, changing cultural boundaries and multiple identities. Through tourism, the media and consumer goods, people from practically all societies are confronted with aspects of other societies and cultures. New styles of consumption (clothing, utilities, food) as well as standardized systems of time, money and expertise are introduced, produced, and distributed anywhere and everywhere by transnational companies.

One organizational feature of this is the transformation of the nation-state and the shift of accents to above or below-state arrangements. There is a transfer of formal state powers to continental 'power blocks' with a steady increase in regulations and effects on regional and local levels. Hence, in this era of time-space compression, social relations become disembedded, that is, they are increasingly 'lifted out' of the context of local interaction to become re-embedded again in different forms and conditions (Giddens 1990). These processes of 'glocalization' (Robertson 1995) refers to the recombination of existing forms and practices into new forms and practices. However, societies are still organized according to the principle of separate national states. Members of transnational communities cannot escape from the power of the nation-state as they try to create and maintain a collective identity and as new boundaries emerge there are determined efforts to affirm old ones (Geschiere & Meyer 1991). The nation-state is still viewed as 'a key socio-psychological source of social cohesion' (Vertovec 1997) although its role as the casing for social and cultural associations renders it subject to change.

This tension-laden situation creates the framework of the negotiating processes that determine governance and use of natural resources. On the international arena, the states are still main actors, although they cohabit the global space with regional economic and democratic actors (EU, ASEAN), with global organizations (UN, WTO, the World Bank, NGO's), and with a growing number of ever more powerful transnational companies. These global and regional actors have in their hands the decision-making systems that will put insights from social-ecological systems research to the test. It is increasingly important that research on sustainable governance and management of ecosystem services is addressing the power issues that are on the agenda of these actors. Experiences

from The United States and Europe demonstrate that while environmental policies have made strong headway the obstacles to applying management principles from science are considerable (Vig & Faure 2004).

The SMI will embark upon new research to consider the realization of social-ecological systems results and methods in environmental and resource negotiations. We have in our research groups already considerable practical experience (see in particular the International Outreach document) but we have far too little systematic knowledge of how new environmental research is being treated among actors in international relations. Thresholds, resistance, and alliance-building are crucial issues to explore further. What are the experiences of expanding the use of new concepts from the local scale to more aggregate political and economic levels? The research we foresee should focus both on the translation of local social-ecological knowledge to generalized implementations and on the natural resource diplomacy and the negotiation arenas themselves.

With few exceptions existing research environments in Sweden have scarce competence on these issues. In building new and solid competence in this theme we intend to develop collaboration with our international research partners, including the IHDP and Donald Bren School of Environmental Science & Management, University of California, Santa Barbara; The Graduate School of International Relations, University of California, San Diego; The Sustainability Science Initiative and Clark University; and International Policy Program at The Paul H Nitze School of Advanced International Studies, Johns Hopkins University, Washington (see letters of support Appendix VIII). We will invite visiting scholars from among such centers to help train our graduate students and postdocs and we will send our own researchers on extended visits to our partner institutes. Adding to the growth of competence is the fact that we can right from the start turn our young researchers to practical problems in our many cooperative projects with states and organizations in different parts of the world.

4.5.2 Power, welfare states and social-ecological systems

The complex adaptive systems approach and institutional theory can be developed further through inspiration from actor-oriented power resource theory. Governance and management of social-ecological systems is often seen as questions of learning, leadership and adaptation, and institutional theory stresses inertia and historical path dependence. But governance can also be seen as a power struggle between political parties, organised interest groups and other social collectives. The necessary change of mental models mentioned above therefore also might include development from institutional theory, to power resource theory, underlining change, actors' intentions, and the power resources available for political action.

Historians as well as social scientists, have paid interest to the influence of the actors in order to reach a more dynamic understanding of social systems. Granted that "politics matter" (Evans et al. 1985, Esping-Andersen 1990, Korpi 2001), what were the objectives of the different political parties, and what influence did they have on the process of political decision-making? Politics is often about choices, and political parties present alternatives for these choices. At the same time, the alternatives available for the individual political party are strongly influenced by other actors in the political system, as well as by the general conditions and rules for the system (Åmark 2005).

The answers to questions as the above have often been formulated within a power resource theory. A possible source for inspiration to research on governance and management of linked social and ecological systems is the comparative welfare state research. Social insurance systems for example constitute strong institutions in the form of legislation, norms, and customs. In order to change such path dependent systems, adequate power resources are necessary (Esping-Andersen 1990, Korpi 1985, 2001, O'Connor & Olsen 1998). Power resource theory has successfully been used in this research to understand and explain both major differences between national systems, each usually dominated by a specific power constellation, as well as the change and development of the institutions in a long time perspective. Mainstream power resource theory has in its turn been

challenged by and combined with institutional theory in a broad, scientific debate, which has resulted in a deeper understanding of mechanisms for change, continuity, and stability of welfare states (Esping-Andersen 1990, Pierson 1994, Korpi 1985, 2001, Korpi & Palme 1998, 2003, Huber & Stephens 2001, Åmark 2005, Carroll & Eriksson 2006). Experiences from this research field can be transferred and applied to the research on governance and sustainability. During the last decades, environmental policy has become established as a policy field in its own right, with a growing institutionalisation in the form of international conventions, national legislation, and organized interest groups on all levels. The scientific challenge is to develop theories, which can handle both continuity and stability on the one hand and complexity, contingency, sudden changes and uncertainty on the other. This is currently lacking.

Sudden changes, such as ecological disasters can contribute to political change through the opening up of windows of opportunities. But opportunities will not result in action, if actors are not in place, prepared to react, and equipped with the necessary power resources to do so. Adaptive systems become complex and uncertain when the power balance between the dominating actors is equal or unclear, as well as when external, drastic changes create new conditions for the power struggle.

Political theory is also needed to interpret ideological struggles between political parties over environmental questions, and type of solutions, as well as priorities between, for example, economic growth or ecological considerations. Typically, liberal parties tend to prefer market solutions, while social democratic parties prefer legislation and states actions. The willingness to establish compromises between the political system and representatives for big firms and the business life can differ between political actors.

We don't intend to try to scientifically prove one type of political solution and ideologi to be more efficient and successful as adaptive management of linked social and ecological systems. Instead, we are emphasizing diversity in management and governance. This means that we want to explore both advantages and disadvantages with all kinds of ideologically decided political solutions.

4.5.3. Security and global change

Environment and security are branches of the same tree. These must be dealt with in the framework for a common political strategy which includes the raising of people's welfare throughout the world at the same time as the values and productive elements of the environment – primarily the ecosystem services, a guarantee for long term welfare – can be maintained. The number of poor people is increasing rather than decreasing in many parts of the world and poverty, due to the acute pressure it puts on local resources and biological diversity, is in itself a major threat to the capacity of ecosystems to generate services (de Gaay Fortman 2003, Hollander 2003). As different parts of the world become increasingly interdependent, the effects on ecosystem capacity and resilience become more complex. Social conditions, health, culture, democracy, and matters of security, survival and the environment are interwoven in a grand panorama of regional and worldwide dependency. Evidence points to a situation where periods of abrupt change due to climatic and global change are likely to increase in frequency and magnitude (Steffen et al. 2004). An emerging urgent question is what such changes mean in a world increasingly divided, with one part highly economically and socially connected through globalization and another, growing, part in poverty, disconnected and without influence? How does inequity on a global scale translate into overall vulnerability to climatic and global changes?

Still, the security issues resulting from resource conflicts, and from unsustainable management of natural resources, "compete" on the international arena with other kinds of natural and human-made disasters. Historical evidence demonstrates that it is often the combined effects of different pressures over time that weaken social-ecological systems and may lead to collapse or disaster (Tainter 1988, Kirch 2005). Most of the important factors are social; it is the interactions between the social and the natural that ultimately give the impact. While this has been studied for histori-

cal societies (see also emergent issue 4 below), often in limited geographical settings – typically islands or small and isolated societies in the distant past – too little attention has been paid to the linking of past experiences with the much more complex and large scale security issues that can occur in globalized societies; the attempt in Diamond (2005) is brave but also clearly illustrates the limitations of our current understanding (see e.g. Hornborg 2005).

Environmental security will therefore have to be managed as integrated with social security and include damage brought by bad social planning, social and economic inequality, terrorism, failed states. The connection between development and the environment has received an established status in theoretical discussions of security. The international relations literature speaks of "comprehensive security" (Hettne et al. 2001), and "environmental rights", as part of human rights issues, are also integrated (Human Rights Dialogue 2004). In reality, however, public involvement is often weak. International environmental diplomacy has without doubt made significant advances and there are now nearly two hundred agreements, some soft, others harder, some binding, others voluntary. But even a list over the ten most successful "international environmental regimes" reveals that this is global environmental policy work done between states and with a minimum of public participation, from the International Convention for the Regulation Whaling of 1946 and the Antarctic Treaty of 1959 via the Vienna Convention for the Protection of the Ozone Layer of 1985 and the Convention on Biological Diversity (1992) to the Convention to Combat Desertification (1994) and the Kyoto Protocols of 1997 (Bryner 2004, Porter et al 2000).

In order to become functional the resource management methods that grow out of the social-ecological systems approach must take these social factors actively into account. The research on social risk science that we seek to build will be closely related to broad, encompassing notions of welfare (see emergent issue 2 above), and will take into account the economic modeling described elsewhere in this proposal. But we will also add perspectives from social scientists and legal scholars, and continue to develop applied research on disaster management and relief, in particular the kinds of disasters that result from weakening ecosystem subject to regime shifts. While some researchers in our team are already working on issues of comprehensive security we will clearly have to strengthen this line of research. We intend to further develop collaboration with the Swedish Institute of International Affairs in Stockholm on security, Tom Downing of the SEI York office on social vulnerability, Roger Kasperson at Clark University on risk and vulnerability issues and also in cooperation with some of our international partners, in particular the Global Institute for Sustainability, Arizona State University, Potsdam Institute for Climate Impact Reseach, PIK and The Tyndall Centre, University of East Anglia Norwich (see letters of support Appendix VIII).

4.5.4 New histories of crisis and resilience

Over the past couple of decades there has been an enormous change in our understanding of human-nature relationships, both in ancient (Crumley 1994, Kirch 2005, Diamond 2005) and in early modern (Warde 2006) and modern (McNeill 2000) periods. Global migration and trade have led to increased populations and has profoundly affected nature, and has also been a decisive factor in determining economic and political patterns of dominance. Western expansion and imperialism have been "ecological" (Crosby 1986, Merchant 1989) and "improvement" schemes have for centuries been put in place to change local and traditional ways of organizing natural resource management around the world (Drayton 2000).

Parts of humanity in the early modern period were, in this way, breaking out of their biological and geographical confines in Europe. Soon this was followed by further emancipation from material restrictions as agrarian and industrial production started growing. By the turn of the century 1800 this expansion prompted Malthus (1798) to present his dismal analysis, but despite repeated later outbursts of neo-Malthusian pessimism the dominant tendency has been to regard human expansion and economic growth as largely non-restricted by ecological and social limits (Linnér 2003). However, limits have been more accepted and pronounced in the last several decades (Club of Rome 1972, Brundtland et al 1987), but mainstream thinking still regards technological pro-

gress, "ecological modernization" (Hajer 1995), or a "decoupling" of growth and disturbance, as the way to confront the ecological costs of growth.
These attempts have fitted well with a general narrative of human progress, led by the West and by Western values. While there are still good reasons to support policy initiatives of this kind there are also signs indicating that the world may not be headed in this benevolent way. If we take longer time perspectives, or if we focus on other features of the past than humanity's progress, we might as well find a human history marked by crises, regime shifts, disasters, and constantly changing patterns of adjustment to limits and confines. Indeed, this now emerges as a new historical meta-narrative, linking humanity's creative past with its destructive consequences and nature-culture interplay. Previous meta-narratives have underscored the breaking out of confines; a new historical understanding needs to accommodate what we are learning of the complexity of human-nature relationships in different time periods and in different parts of the world.

In other words, there is a history of social-ecological systems, and of sustainable governance of natural resources to be written. We do not believe that such a history should depart from the present and "comb" time backwards to find a narrative that suits our current thinking of social-ecological systems. But we believe firmly in building a line of research in environmental history as part of the long standing activities in the Institute, a history that will inform the future.

Indeed, historical analysis is essential to the understanding of all four main research clusters in the Institute. Urban social-ecological systems have changed drastically in the recent past and form today the daily environment of more than half of the world's population and affect cities in the developing world as well as the modern metropolis (e.g. Davis 1998). Governing freshwater management for food and ecosystem services have been studied by economic and social historians. Governance and ecosystem management of coastal and marine systems have been studied from modern eco-historical points of view since the ground breaking studies of regions such as California (McEvoy 1986), and the Mediterranean (McNeill 1992). Adaptive governance of dynamic landscapes have been carefully examined by geographers and historians as part of understanding new dynamics of conservation and how to integrate more efficiently human presence and resource use with long term preservation of diversity and (often contested) landscape values (in a vast literature, see e.g. Adams 1996, 2004, Sörlin 2001).

Although the programme for historical research in the Institute will be able to provide knowledge and insights to all four key research clusters, the initial focus will be on Urban social-ecological systems and Dynamic landscapes. It is increasingly important to understand sustainable spatial planning as a co-production of cities and landscapes. The relations between the two are mutual, interactive, and never-ending. Cronon (1991) demonstrates how, through a wide range of infrastructures, policy decisions, and technological regimes, Chicago and the Great West developed in a lock-step fashion. The Mid-Western landscape "produced", literally, the city, and the city, with its increasing demand of resources and its vigorous trade and economy, equally produced the surrounding landscape. The result was a "remote landscape", a nature shaped by the metropolis, and vice-versa: nature's metropolis. However, only small portions of Chicago's resource flows came from beyond the region. Chicago's "footprint" on distant regions of the world was limited. Today, with growing volumes of flows, the interaction occurs over longer distances and with a spatial distribution that is more patchy, and possibly more unjust, than before, and fundamentally difficult to control with conventional governance. We aim to provide an empirically based understanding of the interwoven character of cities and landscapes in flow-intensive economies operating simultaneously on a number of spatial levels, ranging from the local to the global and how the resilience and vulnerability of this character in relation to complex adaptive systems.

There will also be a focus on the roles of knowledge and science for change of policy. Conventionally we regard growing knowledge as a prerequisite for better resource management, but in reality the relationship between the two is extremely complex. Mismanagement of natural resources could occur in places with the highest possible level of education and with hosts of scientific institutions, as well as in extremely traditional and low-tech societies. The interplay between knowledge

generation, policy, and sustainable governance is crucial for progress in ecosystem management and we need to understand much better how these interactions work and how, and why, knowledge is not always applied rationally. In parallel with resource management regimes we could speak of "knowledge regimes". There is a built-in power dimension which is a central component of the modern knowledge project (Jasanoff 1995, Jasanoff 2004). This can be national and deal with how the political agenda of a particular country is rooted in different scientifically informed models of thought (e.g. Slagstad 2004). But the power dimension can also be global and is then bound to implications within modern Western science and its institutions. This is, for example, how the concept was applied in the document prepared by the African nations for the international summit on sustainable development in Johannesburg in 2002: "The existing technologies and knowledge regimes must be changed." (African Civil Society Forum 2002)

Recent work on the history of global warming demonstrates the importance of a knowledge regimes approach. While early indications of human forced climate change did occur already in the 1930's, it was not until military planning circumstances needed new knowledge of numerical weather predictions and until there was an environmental political agenda set that there was a strong enough "demand side" to make use of the new knowledge that global warming emerged as an acknowledged political and global security issue, and as such it still had decades to go until it reached significance (Weart 2002, Harper 2004, Sörlin 2006). The knowledge regimes, thus, are affected by political action and social events; that is, by human agency. The same basic conditions apply, we believe, for ecosystem management. Better understanding of the dynamics of knowledge regimes will enhance our abilities to carve out viable governance and policy. At the same time, our work will contribute new basic knowledge on important aspects on modern and contemporary societies and their relationship with the environment.

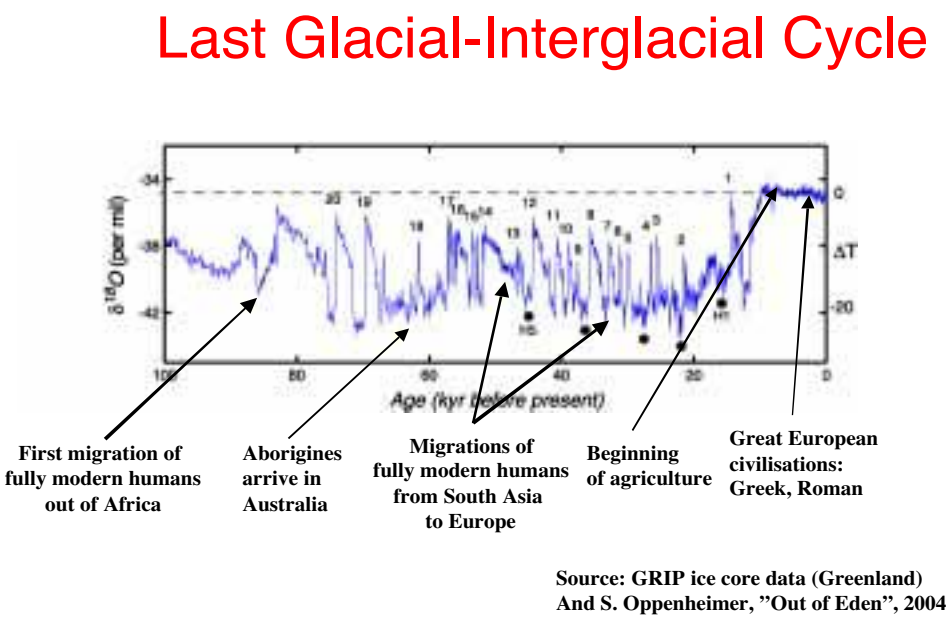


Figure 4.8. Ice core data from Greenland combined with data on human migration and settlement. (from Will Steffen, CRES).

Finally, we have been asked to host the secretariat of the interdisciplinary program Integrated History of People and the Environment (IHOPE) if a SMI will become reality. The focus of IHOPE is to develop understanding of the integrated biophysical and social history of human societies. Human history and earth system history have traditionally been developed independently, and with little interaction among the disparate academic communities. Therefore, separate methods of describing these histories have been the result, and that creates difficulty in integrating information across fields of study. Recent recognition that current earth system changes are strongly associated with the changes in interdependent social-ecological systems make the integration of human history and earth system history an important step in understanding the factors leading to global change and coping and adaptation strategies for the future. There will be close collaboration

with Arizona State University and the archaeologist and anthropologist Charles Redman, Sander van der Leeuw and Joseph Tainter, who are very keen on working with us at a Mistra Institute here in Stockholm. There will also be close collaboration with the Earth Systems Science Partnership, for example through Will Steffen the former director of IGBP and now at CRES, Canberra, Australia (see Appendix VIII letters of support).

The Research platforms

In the proposed research agenda for a Stockholm Mistra Institute we have made clear that the research efforts take a truly integrated social-ecological systems perspective emphasizing complex adaptive systems and cross-scale interactions. There are few research institutes and scholars that have started to address these issues in a robust fashion, merging the natural and social sciences and the humanities in a profound sense. The foundation of interdisciplinary research experience that our joint effort builds upon, developed during the last two decades, provides a solid basis for creating an innovative research arena that will generate new and elaborated insights and means for the development of governance systems and management practices in order to secure ecosystem services. We will have an internationally strong and recognized research platform to start from that has matured to a stage where it now has become possible to take the integration of research on social-ecological systems significant steps forward.

It is our assessment that the numerous activities in environmental research and policy work, focusing on reducing the pressures on the environment through pollution abatement, energy efficiency or infrastructure changes, although very important, are not sufficient for sustainable governance and management of ecosystem services. Such measures implicitly assume that ecosystems will self-repair when pressures are removed. The luxury of living with self-repairing ecosystems, from local to global scales, seems to be history. The challenge in this new situation is to actively enhance and strengthen the capacity of ecosystems to sustain social and economic development. At a minimum it requires understanding of ecosystem dynamics and how it has evolved with human actions over time, management practices that generate such understanding and learn how to respond to environmental feedback, multilevel governance systems that make ecosystem management possible and that have the adaptive capacity to deal with uncertainty and change.

Organizing interdisciplinary research that will make a difference for sustainability is not a simple task. It is difficult to achieve in university departments, where scientists tend to stick to their perspectives and where the baggage of disciplinary knowledge often is too heavy to take on new effort for new understanding. Furthermore, it will not be sufficient to simply open up an area by gathering, in a democratic fashion, multiple disciplines and perspectives from different parts of a university campus. Such an approach may generate some new initiatives but such processes are often very complicated and take too long in relation to the demands for in-depth insights of social-ecological systems to deal effectively with global change. Not even an interdisciplinary approach where researchers meet, discuss, and borrow from each other may be sufficient. Often, such collaboration only marginally develops social-ecological understanding. It is our view and twenty years of experiences that the most effective are interdisciplinary (sometimes referred to as transdisciplinary) problem oriented approaches, where scholars from different disciplines gather around particular issues and are committed to them, actively collaborate on open-minded dialogue arenas, developing shared visions, excitement and trust, drawing on, combining and generating diverse perspectives, theories, methods and techniques. Committed leaders and individuals are required to inspire the search for new insights and allow for explorative research. It is our intent to create and foster such an internationally highly attractive arena if granted the Mistra Institute.

The Stockholm Mistra Institute leadership

We will create a dynamic collaborative research arena in-house that will stimulate innovative and integrative basic interdisciplinary research on sustainability issues in line with and sharing Mistra's vision. The purpose is to allow for in depth interdisciplinary collaboration and at the same time nurturing creativity and innovation. Scientists working at the proposed SMI will perform basic interdisciplinary research, with a problem-oriented focus, to generate deeper understanding and a solid foundation for policy, decision-making and governance of social-ecological systems for sustainability.

The proposed leadership (Folke, Rockström) and the steering committee (Eckerberg, Mäler, Sörlin) of the SMI have extensive experience of such collaboration. Actually, throughout our careers we have had the privilege to actively work on interdisciplinary research arenas. The research institutes behind this application have accumulated experience of transdisciplinary scientific work with collaborative networks of top scholars on the international scene and have achieved internationally recognized results in science, policy and practice. The interdisciplinary collaboration has resulted in hundreds of publications, with more than ten articles in Nature and Science. The research is influencing scientific disciplines and policy in many areas and in different parts of the world. Several of our articles are recognized internationally among the top 1% of cited publications in their fields by the Essential Science Indicators.

The interdisciplinary research tradition of the Beijer Institute, the Royal Swedish Academy of Sciences, under the lead of the economist Prof. Karl-Göran Mäler (cv appendix IV) has centered on ecology and economics, but with a much broader set of social and natural scientific disciplines continuously involved, witnessed in e.g. the major volumes and the large number of research articles that have been generated and in the establishment of leading international research networks like the Resilience Alliance. Prof. Carl Folke (cv appendix IV), interdisciplinary scholar with roots in ecology, has worked as deputy director of the Beijer Institute, and is on the steering committee of the Resilience Alliance. Prof. Folke leads dynamic research teams in his function as director of CTM (that has the objective to foster the integration of the natural and social sciences, law and humanities) and chair in natural resource management, Dept. of Systems Ecology, Stockholm University. The close collaboration between BI, CTM, and associated scientists and PhD-students at Stockholm University is strong and continuous. The collaboration with the SEI started with joint projects, during geographer Prof. Roger Kasperson's leadership, on resilience, vulnerability, environmental risk, and sustainability science and has now intensified with Dr. Johan Rockström (cv appendix IV) as director of SEI. Dr. Rockström is also associate professor in natural resource management, from Dept. Systems Ecology, Stockholm University, with a background in agronomy and freshwater research. The three institutes are briefly described in Appendix IX.

This steering committee of the SMI is considerably strengthened on the social sciences and humanities parts by inclusion of the environmental historian Prof. Sverker Sörlin, Royal Institute of Technology (KTH), Stockholm and Prof. Katarina Eckerberg, political scientist, Umeå University, who will start as deputy director of the SEI in August 2006. Prof. Sörlin, will play a leading role in the Centre in the areas of humanities, history, and the social sciences. Sörlin has conducted and managed a large number of research programmes in Sweden and internationally, has an excellent publishing record, and has worked with advice and served on boards and commissions in environmental and research policy (cv appendix IV). Prof. Eckerberg will play a leading role in coordinating and performing research on governance and management of ecosystem services. Prof. Eckerberg is a top-class social scientist, with a strong research record on environmental policy and political science and with a broad regional coverage of Eastern Europe and the Baltic.

A platform for the next generation of scientists

We are now at a stage when the next generation of highly competent scholars needs to be secured for the future. We have inspired and trained a new generation of young scientists in interdisciplinary analysis and synthesis that are now ready to take on the challenges but that need a solid platform and support to take constructive collaborative and innovative interdisciplinary research on social-ecological systems significant steps further. Most of them have been part of the interdisciplinary PhD and young scientist groups run by CTM. Many of the young researchers are on a path of developing a unique competence and interdisciplinary understanding and some are already known as quite qualified scholars nationally and even internationally (see appendix VII). We intend to bring a substantial group of young scholars together under a SMI by establishing competitive positions that also will attract top young scholars from the international scene. The platform will be very attractive with the possibility of shared positions with leading research groups and institutes worldwide (see international joint research below) and secured carrier paths with university departments, as outlined in the section on the SMI organizational structure.

The scientific mix of competences of the interdisciplinary young scholar group at Stockholm University includes disciplines from all the sciences, e.g. history, economic history, comparative religion, human geography, education (pedagogy), sociology, social anthropology, psychology, political science, economics, law, ecology, botany, computer and systems science, environmental science and their various subdisciplines. Their research on environmental issues and social-ecological systems covers social and environmental psychology and decision-making, ecological economics, environmental and resource economics, institutional economics, comparative environmental politics, governance and institutions, international relations, trade, globalization, transboundary environmental issues, natural resource management, marine ecology, biodiversity, ecosystem management, human health and disease, organizational theory, knowledge systems and learning, agency, actors and network, collaboration, conflict resolution adaptation, sustainable livelihoods, community participation, adaptation, vulnerability, resilience, environmental history, history of land use change, landscape ecology, systems ecology, development policies, policy analysis and decision support systems.

In the group, there is a lot of experience with work on governance and management of urban, marine and terrestrial systems including freshwater, food production and quantification and modeling of ecosystem services. The gender balance is also interesting with 19 female scholars out of 35 (see appendix VII).

The application has significantly benefited from input of the young scientists and we would like in particular to acknowledge Andreas Duit, Victor Galaz, Thomas Hahn, Line Gordon, Annika Dahlberg, Emily Boyd, Per Olsson, Maria Tengö, Fiona Miller, Johan Colding, Anne-Sophie Crepín, Ingela Ternström, Åsa Greger Swartling, Måns Nilsson, Lowe Börjesson.

Research collaboration in the Stockholm area

The location of the SMI will be at the Stockholm University campus, in a joint building between CTM, SEI and staff from the BI. The building is within a short bicycle ride from KTH and walking distance to the Royal Swedish Academy of Sciences, where not only the BI but also the International Geosphere and Biosphere program on global environmental change (IGBP) is located. The collaboration with the IGBP system intensified under its Director Dr. Will Steffen, with joint projects and publications addressing global change issues at different scales and will continue with IGBPs new Director Dr. Kevin Noone and the recent Earth Systems Science Partnership (ESSP) (see letter of support appendix VIII) as will be elaborated on in the next section on international joint research.

We have developed a pool of collaborators, representing different disciplines and Stockholm University departments, where environmental and sustainability issues are in focus. Two persons in this pool have been particularly involved in the development of the proposal. Prof. Thomas Elmqvist, Dept. of Systems Ecology and Prof. Klas Åmark, Dept. of History and active in CTM as chairman of the board. Prof. Elmqvist will play important roles in SMI as an active researcher in the institute and lead coordinator of the research themes on urban issues and dynamic landscapes. Prof. Åmark will participate in relation to the organizational developments, in research on political regime shifts and complex systems, and as mentor for young scholars.

Other researchers in the pool are Prof. Ulf Jonsson, economic history, expert on globalization, food production and economic drivers behind land use change; Prof. Mats Widgren, human geography, expert on development research emphasizing the historical and cultural understanding of causes and effects of land cover change and methods for capturing historical change and bridging the gap between detailed local case studies and generalised macro-scale studies; Prof. Jonas Ebbesson, Director Stockholm Environmental Law and Policy Centre, with a focus on international environmental law, is involved in CTM and collaborates on governance and law related to social-ecological systems. Assoc. Prof. Mona Mårtensson, on local knowledge systems, Assoc. Prof. Christofer Edling, and Dr. Fredrik Liljeros on social network and complexity theory at Dept of Sociology and with the Forum for Learning on Sustainable Development at Dept. of Education.

There is strong support for the development of SMI research and collaboration from Dept. of Political Science (see letter appendix VIII).

There are internationally leading ecologists in the pool including Prof. Ove Eriksson, *plant ecology*, Dept. of Botany, specialist on landscape dynamics across temporal and spatial scales; Associate Prof. Jon Norberg, *natural resource management* and specialist on complex systems and social-ecological dynamics, networks, functional diversity, Prof. Nils Kautsky, aquaculture and *coastal ecosystem management* in tropical countries, Prof. Fredrik Wulff, *marine ecosystem* dynamics and management and Prof. Ragnar Elmgren, *marine and brackish water ecology* at Dept. Systems Ecology; Prof. Georgia Destouni, *hydrologists* and Prof. Margareta Ihse, landscape ecologist from Dept. of Physical Geography and Quaternary Geology; Prof. Henning Rodhe, climatologists at Dept. of Meteorology and Prof. Dag Broman at the Dept. of Applied Environmental Science (ITM). Collaboration with scholars at the Royal Institute of Technology will develop through Prof. Sverker Sörlin and the Office for History of Science and Technology, where particular strengths are in areas such as environmental history, knowledge regimes, infrasystem dynamics, and landscape values. There will also be links to the interdisciplinary research at Linköping University through Prof. Johan Hedrén (social and environmental sciences). We envision that in path with the development of the SMI collaboration will spread into other departments like archeology, philosophy, Stockholm University School of Business, and the Institute for International Economic Studies. We would also like to strengthen research collaboration with Stockholm School of Economics, where currently teaching collaboration is developing.

Research collaboration in Sweden
A Stockholm Mistra Institute would attract research groups in other parts of Sweden to participate, including Umeå University, Luleå Technical University, Gothenburg University and Chalmers, Lund University, Uppsala University, and the Swedish University of Agricultural Sciences. There are already several ongoing and well established collaborations with researchers in other parts of Sweden including joint research, scientific publications, teaching and training programs, seminars and lecturing.

Joint research and collaboration with leading international scientists and institutes
The leadership and the three institutes, BI, CTM, SEI, have a strong collaborative network under continuous development with leading actors worldwide performing interdisciplinary research on social and ecological systems, and their management and governance. The collaboration covers leading researcher in the social sciences, humanities and the natural sciences with expertise from local to global issues, different temporal scales and with an emphasis on complex systems.

In Emma Tompkins report to MISTRA, ten institutes were interviewed. Among those the following are part of our collaborative networks with a keen interested to further develop and strengthen alliances with a SMI, witnessed in their letters of collaboration and support (see appendix VIII).

- the Earth Institute at Columbia University;
- the Gund Institute in the University of Vermont;
- the National Center for Ecological Analysis and Synthesis (NCEAS) at the University of California in Santa Barbara;
- the Natural Resources Institute in the University of Manitoba;
- the Tyndall Centre for Climate Change Research in the UK;
- the Workshop on political theory/Center for the Study of Institutions, Population and Environmental Change at Indiana University.

We are deeply involved with *The Resilience Alliance* (www.resalliance.org), a consortium of researchers and research institutes exploring the dynamics of complex social-ecological systems to discover foundations for sustainability (e.g. Kate Brown, Stephen Carpenter, Lance Gunderson, CS Holling, Terry Hughes, Elinor Ostrom, Charles Redman, Marten Scheffer, Sander van der Leeuw, Brian Walker, Frances Westley). The RA evolved out of research programmes of the Beijer Institute

and BI, CTM, SEI, are members of the network with scholars representing competences from social sciences, humanities and natural sciences (see letter from Brian Walker appendix VIII).

In addition to the RA, we intend to further develop the productive work of CTM, BI, SEI on resilience, vulnerability and adaptation through the SEI network of staff and centers, notably with Dr. Tom Downing, Oxford, leading expert on social vulnerability, who will be deeply engaged in the SMI, and Prof. Roger Kasperson, former director of SEI, Clark University, expert on vulnerability, risks, adaptation and a key person within the Sustainability Science Initiative (SSI), Harvard University. Collaboration with the Tyndall Centre is envisioned as well as with Stanford University and the IHDP (see letter from Neil Adger, Kate Brown, Pamela Matson, Roger Kasperson, Oran Young appendix VIII).

Our three institutes have been strongly engaged with the development and work of the Millennium Ecosystem Assessment through e.g. directors and board members (e.g. Steve Carpenter, Kanchan Chopra, Angela Cropper, Partha Dasgupta, Carl Folke, Roger Kasperson (former director SEI), Thomas Rosswall). We participated, for example, in the early workshops were the direction of the MA evolved (Winnipeg, local subglobal assessments; World Bank, cross-scale dimensions; SCOPE, Paris, ecosystem capacity and scenarios) and particularly in the work of the subglobal assessments. We are very keen to actively participate in the follow-up and further development of the MA in partnership with Diversitas and Unesco (see section on international outreach).

Arizona State University is in a dynamic expansion phase developing research on linked social-ecological systems. We are in close contact with several activities and scholars, e.g. the Global Institute of Sustainability (Charles Redman, Kerry Smith, Charles Perrings) and the new School of Human Evolution and Social Change (Sander van der Leeuw) (see their four letters appendix VIII). Their internationally recognized work ranges from archeology, anthropology to economics and ecosystem science.

The Beijer Institute has developed extensive regional networks of scholars in ecological and environmental economics. In the beginning, the program was implemented jointly with United Nations University's research institute "WIDER" (World Institute on Development Economics Research). From 1995, the program has been run by the Beijer Institute; SANDEE - South Asian Network for Development and Environmental Economics, RANESA the resource accounting network for Eastern and Southern Africa; LACEEP - Latin American and Caribbean Environmental Economics Program and under development MENANEE - Middle East and North Africa Network for Environmental Economics (see letter appendix VIII). The purpose is to teach university teachers through teaching workshops, research seminars etc - activities performed in collaboration with the ICTP (The Abdus Salam International Centre for Theoretical Physics, Trieste) and FEEM (Fondazione Eni Enrico Mattei, Milan). The core aim is to enabling researchers from the developing countries to join the international academic network. Leading scholars participate in the activities and there will be research that develop insights on the new welfare economics and break new ground in relation to economic policy and valuation through collaboration with institutes and researchers at e.g. Resources for the Future, Cambridge University, Stanford University, Johns Hopkins University, University of California, University of East Anglia etc. (see letters by Ken Arrow, Larry Goulder Scott Barrett, Partha Dasgupta, William Brock, Aart de Zeeuw, Kerry Turner, Jeff Vincent, James E. Wilen Tasos Xepapadeas appendix VIII).

A very exciting research arena is developing at University of Wisconsin, Madison, with high-level transdisciplinary research through efforts of the Center for Limnology and world famous ecological research programs, Nelson Institute for Environmental Studies, with strong research on the social dimension of collaborative and adaptive management and governance, the Center for Sustainability and the Global Environment and economists at UW. At a SMI we intend to intensify the collaboration with this group into innovative work (see letters by Steve Carpenter, Frances Westley, William Brock appendix VIII).

SMI will make it possible to take work on governance and management of ecosystem services substantial steps forward by creating, intensifying and increasing collaboration with other world leading groups, for example the ARC centre of excellence on marine science (see letter from Terry Hughes); CRES at Australian National University on social-ecological systems at different scales (see letter from Will Steffen); Emory University on adaptive management and governance (letter Lance Gunderson); Center for BioComplexity and Princeton Environmental Institute on e.g. complex systems, scale and biodiversity (letter Simon Levin); Center for Environment and Society, University of Essex on social capital, collaboration and participation (Jules Pretty); Center for Systems Integration and Sustainability, Michigan State University on networks, institutions and governance (letter T. Dietz, W. Taylor, J. Liu, K. Frank); Donald Bren School of Environmental Science & Management on multilevel governance (letter Oran Young); International Water Management Institute, IWMI, Colombo on freshwater challenges from local to global scales (letter Frank Rijsberman); University of Alaska Fairbanks on resilience issues (letter Terry Chapin); Institute of Economic Growth, University of Delhi on e.g. urbanization (letter Kanchan Chopra); the Sustainable Development Research Initiative, SDRI, University of British Columbia on complex systems framework, participatory approach and transdisciplinary (letter John Robinson) and Potsdam Institute for Climate Impact Reseach, PIK on interactions between biophysical processes and societal dynamics (letter John Schellnhuber).

In building the Institute we will draw on the experiences of the National Center for Ecological Analysis and Synthesis, Santa Barbara, USA, financed by NSF. NCEAS has the principal goal to encourage development of creative transdisciplinary ideas and analyses and syntheses. Since 1995, NCEAS has hosted 3,500 individuals and supported 370 projects that have yielded more than 1,000 scientific articles and NCEAS is widely regarded as a very creative and successful institution. At NCEAS, 10 years of experience has shown that focused working groups of up to 20 scientists coming from a diverse set of scientific disciplines working for a few weeks (generally smaller groups and longer stays are most effective) has been exceptionally productive and successful. We intend to run similar series of working groups at SMI, where each working group typically meets twice a year.

In this context, the Director of NCEAS, Jim Reichman, is quite keen on developing close collaboration with a SMI with the proposed leadership (see letter appendix VIII).

We also have strong links with global change programs and we intend to intensify this collaboration under a SMI.

- **IGBP**- The International Geosphere-Biosphere Programme studies the interactions between biological, chemical and physical processes and human systems (letter form Kevin Noon, appendix VIII) (www.igbp.kva.se).
- **IHDP-** The International Human Dimensions Programme on Global Environmental Change, IHDP's mission is to generate scientific knowledge on coupled human-environment systems, achieve comprehensive understanding of global environmental change processes and their consequences for sustainable development (letter Oran Young appendix VIII).
- **Diversitas** is an international programme promoting an integrative biodiversity science, linking biological, ecological and social disciplines in an effort to produce socially relevant new knowledge (letter Michel Loreau appendix VIII).
- **ESSP** - The Earth System Science Partnership is a joint initiative of the four global change programmes: DIVERSITAS, IGBP, IHDP, WCRP**.** ESSP brings together researchers from diverse fields, and from across the globe, to undertake an integrated study of the Earth System: its structure and functioning; the changes occurring to the System; and, the implications of those changes for global sustainability.

- **Tyndall Centre** The Centre brings together scientists, economists, engineers and social scientists, who together are working to develop sustainable responses to climate change through transdisciplinary research and dialogue on both a national and international level (letter Neil Adger, Kate Brown appendix VIII).
- **UNESCO/MAB,** The Man and the Biosphere Programme, proposes an interdisciplinary research agenda and capacity building aiming to improve the relationship of people with their environment globally. It uses its World Network of Biosphere Reserves as vehicles for knowledge-sharing, research and monitoring, education and training, and participatory decision-making (letter Natarajan Iswaran)

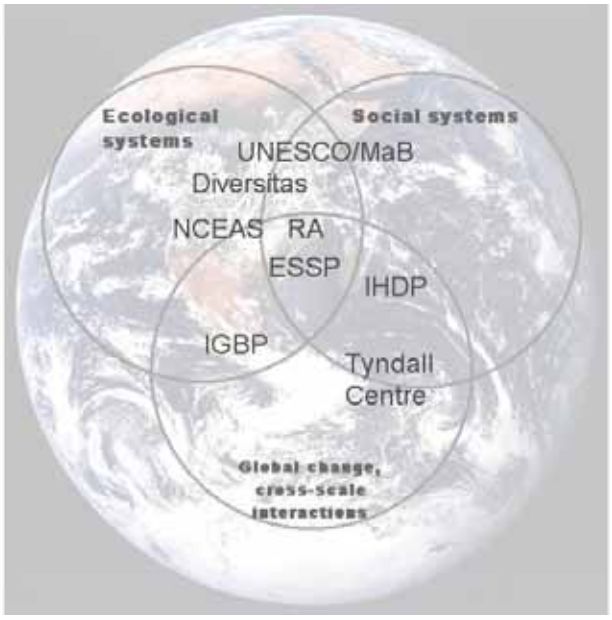


Fig 5.1. Major international global change research collaborators

We have plans for developing long-term and continuous collaboration with the extensive network of internationally leading research groups should we be granted the SMI. The collaboration includes;

- establishment of joint research positions (both junior and senior research positions);
- exchange of post docs and researchers;
- support for sabbaticals and visiting scientists;
- development of joint research initiatives, collaborative research and joint workshops;
- creation of platforms and projects for innovative participatory learning and syntheses

The Stockholm Seminars in Sustainability Science and Policy, a joint seminar series of the Beijer Institute, CTM, SEI, and IGPB, reflects the attractive arena that Stockholm plays on the international interdisciplinary scene. Over the years we have had about seventy seminars with leading researchers. Recently with, Prof. Steve Lansing, Santa Fe Institute, with whom we initiated plans for collaboration under a SMI. In April and May 2006 there will be seminars with Prof. John Robinson, University of British Columbia, Dr. John Anderies, Arizona State University, Prof. Douglas Meffert, Tulane and Xavier Universities and Prof. Oliver Coomes, McGill University. Several researchers have shown their interest to move to Stockholm and work with us in a Stockholm Mistra Institute, including Prof. Joe Tainter, Prof. David Waltner-Toews, and Associate Prof. Garry Peterson.

6 Organization

The proposed organisation of the new Stockholm Mistra Institute (SMI) is aimed at creating a full-fledged autonomous institution, with an institutional and governance framework conducive for a world-leading research organisation. The process of building such an institution will require strong leadership, scientific vision, commitment, and flexibility as the institution evolves. SMI will operate from Stockholm University and within Swedish university laws and university policies and regulations.

Stockholm University has given the Mistra initiative enough independence to allow for the development of a flexible but also strong and well-focused institution. This will give the SMI the autonomy it needs, while also securing unimpeded access to the research pool of the University and its full institutional support. Institutional autonomy will also place the SMI in the best possible position to draw on the resources of the core partners: the Beijer Institute and the Stockholm Environment Institute. The proposed organisation for the SMI will be structured as described in the following.

6.1 Organisational structure

We intend to fully heed Mistra's advice that successful interdisciplinary centres can only grow slowly and progressively, driven by a strong sense of shared purpose, while producing a critical mass of knowledge. The sense of shared purpose among the core partners emanates strongly from the proposal. We suggest an innovative structure where a physical global hub with a carefully crafted critical mass is established at an early stage. We believe that this will allow the Mistra Institute to grow and excel progressively through strategic recruitments, partnerships in Sweden and internationally, and through research achievements.

Key factors guiding the organisation of SMI include :

1) a high national and international profile,
2) autonomy within the university structure,
3) synergies with university faculties,
4) transparency through clear, simple and democratic governance structures,
5) flexibility to manoeuvre along strategic and novel research avenues
6) built in benchmarks for assessing and evaluating progress. The core partners,

SU/CTM, Beijer Institute and SEI, have far advanced plans of how to establish a scientifically strong interdisciplinary organisation platform for the new Mistra. Each will contribute staff, resources and research thus generating added value to what each partner would produce on their own. To ensure a strong capacity for outreach and policy impact, we will furthermore integrate Albaeco, a Swedish institution bridging sustainability science to society, within the physical location of the new Institute (Fig. 6.1).

In addition to the three key actors (SU/CTM, Beijer, SEI) the Institute will have close links to a large number of research networks and partners, to allow for flexibility and dynamics (Fig. 6.1). The objective is to create an independent Institute, enriched by the close and interdisciplinary exchange between core partners, partner institutions and research networks. Our aim is to establish an international attractor of the most qualified scientists in the world, who will pursue research through collaboration with students and scientists resident at the Institute. In Stockholm, the International GeoBiosphere Programme (IGBP) and the Stockholm International Water Institute (SIWI) will be actively involved with the Institute to allow for joint projects and synergies. There will also be collaboration with scientists at the Royal School of Technology (KTH). (see support letter from the Rector Anders Flodström, Appendix III).

International networks with top scientists (e.g. Resilience Alliance, Sustainability Science Initiative, Vulnerability Net, ESSP, IHOPE etc.) will be directly linked to the Institute with co-funded positions

and top level workshops organized regularly. The Stockholm Environmental Policy and Law Centre at SU will closely collaborate with the new SMI and scientists from all faculties within Stockholm University will also be associated with the SMI. The Institute will continue, and develop further, already established links with agencies, policy and development institutions, through continuous exchange and collaboration. This applies to both Swedish agencies, such as Sida and the Swedish EPA (SNV), as well as European institutions, such as the EEA (European Environment Agency), and the European Commission, and global institutions, such as UN agencies, particularly UNEP, UNESCO, FAO and UNDP, the World Bank, CGIAR (the Consultative Group on International Agricultural Research), ICSU (International Council for Science) and others.

We intend to put a strong emphasis on relevant research and policy networks, such as the RING Alliance (a global network of environment and development NGOs and research organisations) and the PEP (Poverty and Environment Partnership, a global network of donors and key research NGOs, led by UNDP and UNEP). With all of these there are already existing relations, and the SMI will be interested in opening up more links to new organizations when it is useful for our scientific and policy dialogue ambitions.

Stockholm MISTRA Institute (SMI) on Sustainable Governance and Management of Linked Ecological and Social Systems

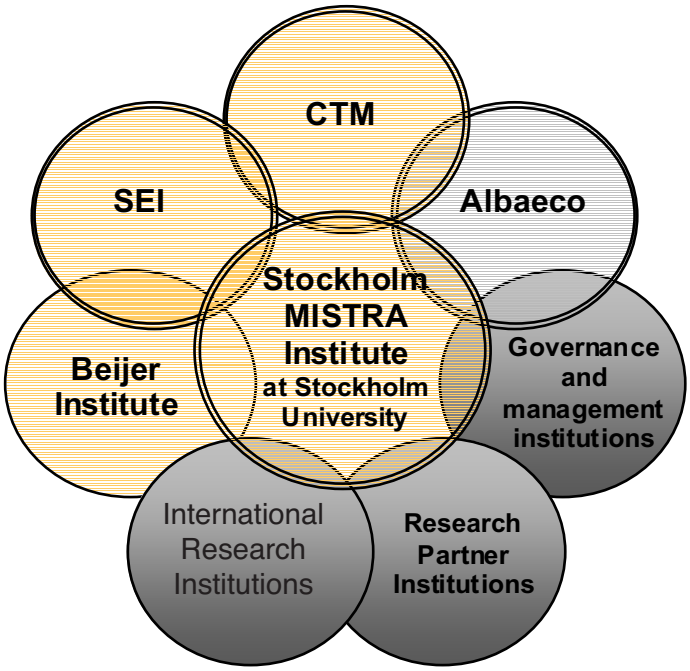


Figure 6.1. *Structure of proposed Mistra Institute. The Beijer Institute, CTM with all faculties at Stockholm University, and Stockholm Environment Institute (SEI) will as core partners (light shaded) contribute research staff and projects to the Institute. CTM, SEI and Albaeco will relocate its offices to the same physical location at Stockholm University (double-lined circles), and be co-located with the new Mistra Institute. International Research Networks will be linked to the Institute, contributing scientific knowledge and exchange of researchers. Partner Institutions will contribute research staff in SMI research activities. The SMI will be closely linked to agencies, policy and development institutions dealing with issues related to sustainable governance and management of social-ecological systems.*

The Institute will play a central role in the overall profile of Stockholm University and will be placed directly under the university management, above the faculties (Fig 2). The uniqueness and strategic importance of this organisational setup is manifested by the fact that only one other institution has this status at the University, namely CTM. The strategic placement of SMI directly under the Management of the Stockholm University and outside of the disciplinary mandates of the four faculties of natural sciences, social sciences, law and humanities, marks the interdisciplinary nature of the work of the Institute and the high priority that the leadership of Stockholm Univer-

sity gives to the new Institute. It is also a sign of the autonomy and flexibility with which the Institute will be able to act vis à vis the faculty organization, while at the same time being able to draw on the strengths and networks across the university.

6.1.1 International board

The SMI will be governed by an international board, which is operationally responsible for the strategic direction of the Institute, the scientific and outreach achievements, the organisational structure and development, and the financial performance of the Institute.

We suggest the following composition of the board: a) an internationally appointed chair, and b) a board composed of a maximum of 10 elected members (11 with the chairperson). Three of the members should be from the three core partners (one each by CTM, BI and SEI), and one member will represent the Institute staff. Four board members will be internationally reputed researchers, with the aim of securing a good balance between scientific disciplines, gender, and nationalities. We intend to invite one representative from industry/private sector and one from policy/governance. We suggest that Mistra is invited on the board as an observer. The Institute and Science directors will be ex-officio members of the board.

The members of the board will be nominated by the core partners, and appointed by the Vice-Chancellor of Stockholm University. The SMI board will nominate the leadership of the Institute (Institute Director, the Science Director, and a Deputy Director), positions which will be appointed by the University Vice-Chancellor.

We estimate that the SMI board will meet approximately twice per year, at least in the Institute's initial build-up phase (year 1-3). Board meetings could sometimes be organized back to back with scientific conferences in order to facilitate a higher frequency of meetings.

6.1.2 Institute chairperson

As chairperson we intend to recruit an internationally leading, senior researcher with strong experience from interdisciplinary science and from science to policy interface, who is well connected to relevant networks and has a solid institutional experience. Our profile for a chairperson includes understanding of complex social-ecological systems and of sustainable governance and management, a strong and respected international track-record on science and leadership, experience from large program and/or institution building processes, with manifested entrepreneurial skills and enthusiasm to the task at hand. We need a communicator, with vision and mission, who can also function as a strong ambassador for the Institute world-wide.

We believe we have found the right candidate for this challenging task. We have initiated a dialogue with Dr Walter Reid, who was the Director of the Millennium Ecosystem Assessment (MA). Walter Reid has a solid and internationally recognised scientific background on complex social-ecological systems, and has built up a very strong international respect and reputation in the field of sustainability research and in leading large science for policy processes. He has declared interest in taking on the role as Chair of the Mistra Institute board if it were awarded to Stockholm.

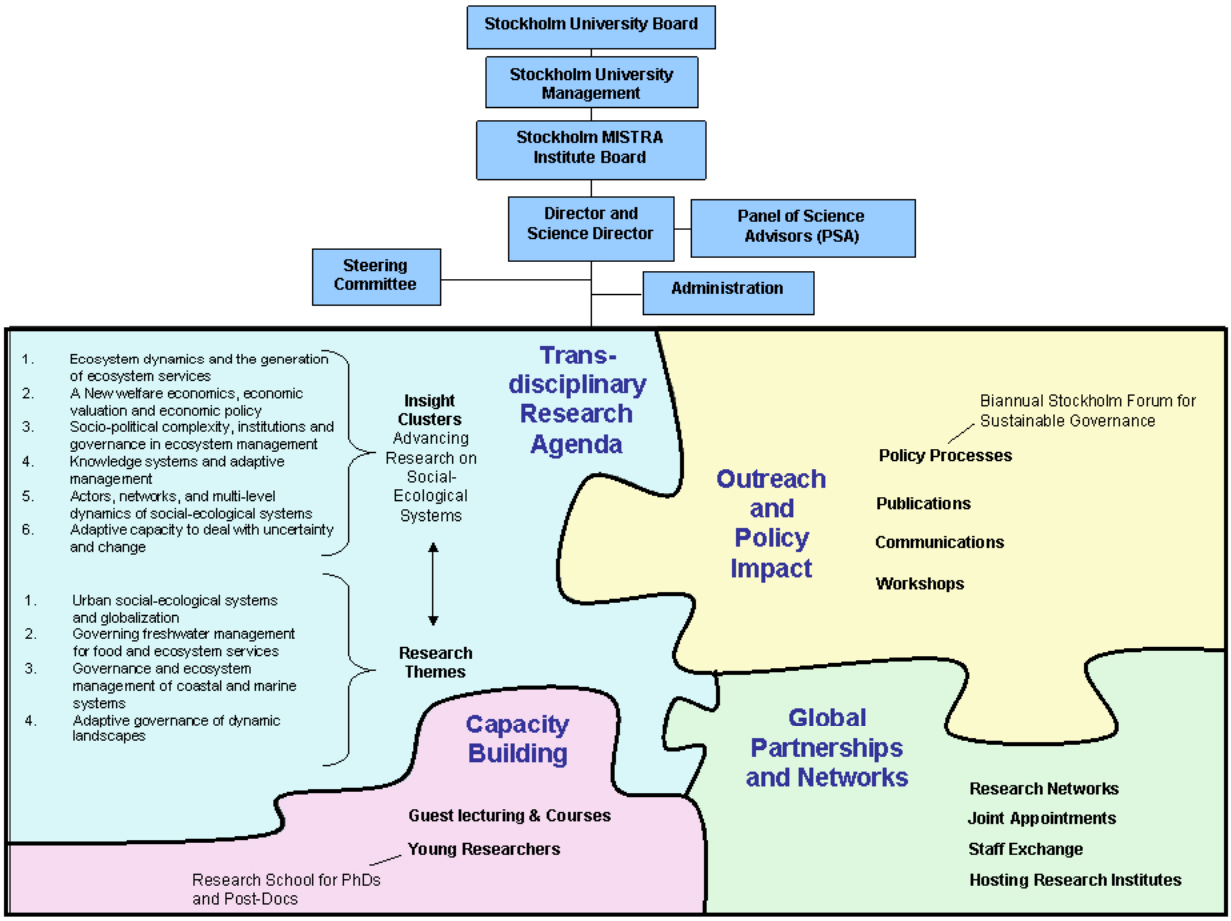


Figure 6.2. *Proposed organisation structure of the MISTRA Institute. The SMI is placed directly under the Stockholm University Management. An international panel of science advisors (PSA), an internal steering committee, and an administrative unit, will support the leadership of the Institute. To mark the integrated nature of institute activities, both within the research programme, and between research, outreach, partnerships, and capacity building, the organizational structure is described as an interlinked whole. Each domain will have clear leadership, mandate, budget and tasks.*

6.1.3. Statutes of the Institute

Statutes for the Institute, including the authorities and structure of the Institute board, will be agreed upon between SU, BI and SEI and approved by the Stockholm University Vice-Chancellor. The Statutes will be designed to give the Institute a highly independent position, and the Institute board will be given a broad authority over the Institute (See tentative Institute Statutes in Appendix V).

The board will be given the authority to decide on all questions of principal importance for the Institute. Operational rules will be developed, with clear relations between Stockholm University, the core partners and the Institute. The leadership at the three core partner institutions (SU, BI and SEI) support the suggested directions of the statutes for the Institute. The SEI and Beijer boards have given their strong support to the establishment of the Institute, and have been consulted on the suggested governance structure (Appendices II, letters of support from the permanent secretary of the Royal Swedish Academy of Sciences, Gunnar Öquist and the Chair of the SEI Board, Lars Anell).

6.1.4 Principles for decisions, strategic directions and conflict resolution

The statutes of the Institute will enable an organisational setup aimed at establishing a simple flexible structure, with as much operational power as possible concentrated to the Institute level (large executive powers to the Institute leadership and Institute board).

Following the presentation on Statutes above, the objective is to give the Mistra Institute autonomy on decisions regarding economics and scientific priorities. The SMI will operate as an independent entity, with its own budget, disconnected from the decision making structures at the faculty level of the University. Stockholm University will supply new grants to achieve the requirements for co-funding of the SMI. SU, SEI, BI and KTH will all contribute staff and research projects to the Institute. The Institute board will be responsible for the financial development of the Institute, and will approve financial reports and budgets. The Institute Director will be given the full executive powers on strategic decisions taken by the Institute board.

The Institute will pride itself with a strong focus on its own sustainability, adopting a modern environmental policy. We will adopt legal regulations and modern principles for staff participation and democracy, adopt an active gender and equity policy, and set in place regulations and procedures for personnel management and staff development. The Institute will apply university standards for employment conditions, with adequate insurance and pension arrangements.

Conflicts, if they arise, which cannot be resolved within the Institute or by the Institute board, will in the first instance be reverted to a small council aimed at negotiating consensus based decisions, consisting of the Vice Chancellor of Stockholm University, and the directors for the Beijer Institute and SEI. It is understood that the Vice Chancellor of Stockholm University is the person ultimately responsible for resolving conflicts related to the Mistra Institute.

6.2. Research organization

The proposed Institute organization reflects the aim of achieving autonomy and flexibility. At the same time we intend to assure transparency and efficiency in decision making, and the ability to lead and carry out interdisciplinary world class research, of relevance for and impact on sustainable development. We will establish a loose organizational structure, which allows for creativity and cross-disciplinary exchange along the iterative learning process between knowledge generation, exchange with policy and society, building partnerships and capacity building. The organizational structure in Fig. 6.2 reflects this ambition.

The structure will be based on flexible interacting groups and activities, with clear responsibilities for research, outreach and policy impact, partnerships and capacity building. The purpose is to create an arena that performs high quality interdisciplinary research, a continuum from science to policy, and the ability to close down research areas and initiate new research.

The proposed transdisciplinary research agenda of the new Institute will be structured around "Insight Clusters" advancing research on social-ecological systems and sustainable governance, and innovative, complementary, applied research around key cross-cutting "Research Themes", as shown in the organization chart (Fig. 6.2). This research agenda will be initiated from the start of the Institute activities, building on ongoing interdisciplinary research currently carried out by the core partners and through strengthened collaborative research with Swedish and international partners (see the section on research platform).

As pointed out in the Research Agenda, the Mistra Institute will embark on new research on emerging issues, and have the capacity to direct research in new strategic directions.

The research themes are strategic areas of basic and applied research that will be carried out in different locations in the world together with partner institutions. The thematic research will closely interact with the "Insight Clusters" on advancing the theoretical framework on governance and management. Moreover, we envisage close interactions between thematic research areas, which will involve cross-thematic syntheses and scenarios research.

Each Insight cluster and Research theme will be led by a Professor or other qualified senior researcher. Professor Carl Folke will lead the cluster theme on Ecosystem dynamics and the gene-

ration of ecosystem services and the cluster theme on Knowledge systems and adaptive management; Professor Karl-Göran Mäler the cluster on Implications of dynamics for welfare economics, economic valuation and economic policy; Professor Katarina Eckerberg the clusters on Socio-political complexity, institutions and governance in ecosystem management, and on Actors, networks, and multilevel dynamics of social-ecological systems; and Professor Tom Downing the cluster on Adaptive capacity to deal with uncertainty and change. Professor Thomas Elmqvist will lead the research themes on Urban social-ecological systems and globalization and the theme on Adaptive governance of dynamic landscapes; Dr Line Gordon and Assoc. Prof. Johan Rockström on Governing freshwater management for food and ecosystem services; Prof. Carl Folke for Governance and ecosystem management of coastal and marine systems.

Each research theme will go through scientific and relevance evaluations after each phase, and be reconsidered if found necessary. Prof. Sverker Sörlin will be responsible for the coordination and bridging of the four themes through integration of the four cross-scale research issues (addressing international relations, power, security, and evolution of crises in relation to governance and management of social-ecological systems) across the four themes.

A special emphasis will be to gradually tap into the scientific competencies across the departments of Stockholm University, and other research institutions, chiefly in the Stockholm area but potentially with groups nation-wide. We intend to engage senior researchers as mentors and discussion partners with the younger scientists in their fields. This task will be especially important during the build-up phase of research on the different themes. For example, Professor Klas Åmark (History) will serve as mentor for research on Power, welfare states and social-ecological systems. A key objective is to further develop strong international partnerships and embark on joint international research through a series of windows for collaborative research and capacity building (Fig. 6.2):

- Joint appointments between the SMI and international and Swedish institutions (project appointments over years)
- Staff exchange where research staff move between the SMI and international research institutions for shorter period of time (months)
- Sabbaticals where researchers around the world are offered to spend research time at the SMI (normally for up to a year).
- A "Young scientists and scholars program", including PhD and Post-Doc positions to build new research and the next generation of interdisciplinary researchers.

Several of the international research groups that support the SMI application are very keen to develop such a collaboration (see the research platform section and appendix).

We expect to enhance the careers of the coming generations of scientists and scholars in this field, but we do not envision this to happen only through internal recruitment and training of the Institute's own PhD students and Post-doc researchers. Rather we expect our young researchers to leave for shorter or longer periods to other leading research environments, while we expect the SMI to attract top researchers from our partner institutions and beyond. The intention is to become a strong node in a truly global network of knowledge flows and exchange.

6.3 Science and Society

The Institute will be organized to enable an effective and iterative exchange between science and society. This will achieved through outreach, including action research methodologies (including stakeholders in the research defining process), research dissemination, policy communication, workshops and seminars, and publications. The organization will be structured to build on already existing, strong capacities for information and policy outreach to media, policy processes and decision making bodies (see the sections on knowledge platform and international outreach).
An internationally appointed Panel of Science Advisors (PSA) will guide the research agenda of

the SMI. This body will be a small group of 5 – 7 internationally recognised scientists, with a balanced representation from the social and natural sciences. The objective of the PSA will be to guide the leadership of the Institute on scientific issues, within the framework of the research directions stipulated by the Institute board.

The Institute Director will have a small internal steering committee at his disposal, of senior staff working at the Institute, to consult with on operational questions (covering both management and research processes). This will be of particular importance during the build-up phase of the Institute. Such a group strengthens the decision-making capacity of the daily leadership, as well as keeps the leading persons at the institute well informed on institutional matters. This steering committee will be composed of a small group of strong, interdisciplinary senior scientists with a track-record of research management, and will include the following persons; Ass. Professor Johan Rockström (Institute Director), Professor Carl Folke (Science Director), Professor Karl-Göran Mäler (economics), Professor Sverker Sörlin (humanities); Professor Katarina Eckerberg (political science), the Deputy Director of the Institute (not identified) and the Administrative head of the Institute (not identified).

The steering committee will link joint leadership with clear distribution of responsibilities. The Science Director will be responsible for the research agenda, the Institute Director for Institute development, the Administrative head for personnel, staffing models, and administration, and we foresee that the Institute Director will be responsible for international and Swedish partnerships. The Deputy Director will be in charge of outreach and capacity building.

An important principle is that all persons in the steering committee also have substantial room for own research and responsibilities within the Institute's research, outreach, policy and capacity building agendas (except for the Admin Head), as an institute of this calibre needs to be led by internationally well recognised researchers in order to have influence on the international scene.

The daily management of the institute will be handled by the director, the deputy director, the scientific director, and a specially recruited administrative head. The administrative head will handle questions about localities, economy, personnel, computers etc., and will report to the Director.

Outreach activities of the Institute, including publications, information, media, policy processes and workshops, will be integrated with the resources already available at CTM, SEI, BI and Albaeco. The new Mistra supported outreach capacities will be integrated into one collaborative team. This will result in very significant synergies, establishing what most likely will be the most substantive sustainability research for policy outreach capacity in Sweden.

6.4 Institute location

There will be, already from the start, a location for the SMI, at Kräftriket, one of the campus areas of Stockholm University with suitable buildings immediately available which is conducive for novel and interdisciplinary research. As stated in the section of the Vice Chancellor there will be a core support from Stockholm University for the Institute, of up to 3 million SEK per year, which initially will be used to cover office costs for the Mistra Institute. We also believe that even though the Mistra Institute will grow gradually, it is of critical importance that a critical mass of strong interdisciplinary research capacity is established already at the outset. This will be accomplished by relocating SEI, CTM and Albaeco together with the Mistra Institute immediately from the start. This will create, once the Mistra Institute is fully operational, an interdisciplinary research environment with some 115 staff or more (approximately 50 - 60 staff physically located in a fully operational Mistra Institute, 50 staff for SEI, 10 staff from CTM, and 5 staff at Albaeco).
Negotiations for securing new offices have already begun with the Stockholm University, and we

are optimistic of a positive outcome, already from 1st January 2007. SEI has reached an advanced planning stage for a relocation to the Stockholm University campus. Similarly, the Director of Albaeco, Dr Fredrik Moberg has agreed to move Albaeco to the new Institute already from the start of the Institute build-up, as will CTM, after an agreement by Carl Folke, Director of CTM, with the Vice-Chancellor of Stockholm University.

The Beijer International Institute of Ecological Economics, already located in the Frescati area at the Royal Swedish Academy of Sciences, will locate research staff of the BI within the SMI, without moving its total operations from the Academy. The three consortium organizations (SEI, CTM and BI) will merge current activities on sustainable governance and management of linked social-ecological systems under the roof of the SMI and further develop such activities in a strongly integrated manner within the new institute.

The SMI will benefit greatly from the joint location of Albaeco, BI, CTM, and SEI. The four institutions complement each other in interdisciplinary themes and focus of sustainability science and policy bridging. The BI will contribute expertise on ecological economics in relation to complex social-ecological systems and implications for economic policy and welfare. CTM will function as the scientific hub of the SMI to scientific excellence at Stockholm University, and assure that the new Institute is fully integrated in the normal academic context at the University.

SEI will particularly offer the links to policy processes and the opportunity to translate and convey scientific results from the Mistra research to policy, governance and management. The three strong environments, in wide international partnerships all over the world, will inject real-world challenges for sustainable governance and integrated management of complex social and ecological systems. Albaeco will offer a powerful capacity for outreach and policy dialogue.

6.5 Leadership

In her review, Emma Tompkins (2005) emphasizes the importance of leadership, from three key perspectives as critical elements for success in establishing interdisciplinary centers – (1) the need for complementary management with a profile as fundraiser, professional management and senior academic steering, (2) the need for scientific champions to attract young adepts and (3) a leadership group who trust and work well together. We believe we have established a core leadership, which fulfils these important criteria.

The core group of senior scientists at the BI, CTM, SEI and KTH who will lead the Mistra Institute, share common interdisciplinary values and perspectives, and have a long track record of joint research. SEI evolved from the Beijer Institute in the late 1980s, CTM and BI have shared joint leadership and collaborate actively since many years, and all three have several joint research activities (e.g., the Stockholm Seminars, joint PhD student groups, and collaboration on science outreach).

As described under the organisational structure above, we suggest a shared leadership of the Institute, with an Institute Director and a Science Director at the helm. Associate Professor Johan Rockström, Executive Director of SEI is proposed as the first Director of the Institute, and Professor Carl Folke, Director CTM and Chair at Dept. of Systems Ecology, SU, is proposed as the Science Director of the new Institute (CVs in Appendix IV). This is a strategic leadership setup, combining two internationally highly recognised scientists, who have a long and very close collaborative track-record, who offer complementary research skills, and who present complementary skills on management and leadership.

Together, Johan Rockström and Carl Folke have carried out several joint research programmes, jointly supervised PhD and Post Doc researchers, and have published pioneering research together (e.g. Folke et al., 2002; Rockström et al., 1999). Both share a common scientific vision, and the

ambition and sense of responsibility to bridge science and society to enable a transition towards sustainability. Both are deeply committed to research capacity building of young scientists, and both nurture complementary global research and development networks. Rockström has a remarkable track-record on research management and leadership, ranging from building regional programmes, developing an interdisciplinary research capacity building institution in sub-Saharan Africa, to leading a large global research institute. His research on freshwater and sustainability is at the very research front worldwide, and his ability to build interdisciplinary research programmes, and link science with policy and development, will be very valuable for the Mistra Institute. Folke has established himself as a leading authority on resilience research and has built a dynamic research group at Stockholm University which constitutes a prominent global hub of interdisciplinary research on resilience and sustainability in various contexts and systems (Janssen et al., 2006). The combination of scientific rigour, capacity to generate novel research insights, and an interdisciplinary worldwide recognized track-record on advancing research on social-ecological systems, makes Carl Folke an ideal Science Director for the new Institute.

Our strategy is to have the close dual leadership team of Johan Rockström and Carl Folke to lead the Institute during the build-up phase of the Institute (years 1 – 3), with a high time allocation from the start. This may progressively increase further once the Institute is in full operation. Johan Rockström and Carl Folke are fully committed to take on the role of leading the new Mistra Institute. Carl Folke will devote 80 % time to the role as Science Director of the Institute, maintaining 20 % with CTM, which will secure a close synergy between the Mistra Institute, CTM and teaching and training at Stockholm University. Johan Rockström will commit 50 % time to the role as Institute Director. The process to make this possible is already in place, through the recruitment of two deputy directors at SEI starting 1st August 2006 (normally SEI is operated with one deputy director). We have agreed that, if circumstances require, both Johan Rockström and Carl Folke may further increase their time commitment already during the course of the first three years.

We see the (50% + 80%) integrated leadership arrangement during the build-up phase as an optimal solution to meet Mistras vision for the new Institute. Not only does it combine entrepreneurial and scientific skills, it also enables unique synergies with the three key institutions that will be determinant for the success of the SMI – Stockholm University, Beijer Institute and SEI. By keeping the links to the Beijer Institute, CTM and the University, we will be able to maintain engagement in research supervision, teaching and coordination of research programmes. The strong link that will be established between the Mistra Institute and SEI, will secure synergies particularly on policy integration, international research partnerships, and a wide set of research capabilities.

We intend to recruit a full time Administrative head, and a full time deputy director (who will work part-time on management and part-time on research). In addition, the senior researchers in the steering committee will allocate significant staff-time in the Institute as senior researchers and thematic leaders. Professor Sverker Sörlin, professor of Environmental History at The Royal Institute of Technology (KTH), Stockholm, has accepted to play a leading role in the Institute in the areas of humanities, history, and the social science. He has conducted and managed a large number of research programmes in Sweden and internationally, has an excellent publishing record, and has worked with advice and served on boards and commissions work in environmental and research policy.

Professor Katarina Eckerberg, currently at Umeå University, has been recruited as the Deputy Director of SEI, starting 1st August 2006, and will form part of the senior leading researchers of the Mistra Institute. Katarina Eckerberg is a top-class social scientist, with a strong research record on environmental policy and political science and with a broad regional coverage of Eastern Europe and the Baltic.

Professor Karl-Göran Mäler, Director of the Beijer Institute is a worldwide renowned and highly respected economist with publications that have influenced environmental and resource economics in major ways. He has served as advisor to both national and international bodies and will

develop the research agenda on complex systems and implications for welfare theory and economic policy. Prof. Mäler will retire as a Director of the Beijer Institute at the end of December 2006 and a new Beijer Institute director to be appointed may become involved with the SMI.

6.6 Staffing strategy

6.6.1 Start-up phase 2007 - 2009

If Mistra approves our application, the first measure taken will be to establish the board for the institute, as well as the core leadership of the Institute. The five persons identified above as first members of the steering committee will be able to begin their work at the Institute directly, i.e. Janury 1st, 2007 (Johan Rockström, Carl Folke, Katarina Eckerberg, Karl-Göran Mäler, and Sverker Sörlin).

A high priority will be put on appointing an administrative head, and during the course of the 1st year we intend to recruit a deputy director and an administrative assistant. Our aim is to recruit 1 international senior researcher to the Institute during the 1st year, and 1-2 externally recruited research positions will be filled and at least one young researcher will be recruited externally. From the three core partner institutions (Beijer, CTM and SEI), an estimated 6 – 9 researchers will be placed at the Mistra Institute (some with shared positions between the Mistra Institute and the core partner institution). Finally, we aim at attracting 1 joint position with an international partner and 1 - 2 senior guest-researchers for an initial batch of visiting scientists at the Institute.

We will contribute 3 PhD students and 2 Post-Doc researchers to the Institute during the 1st year, which are currently under recruitment in the FORMAS supported Centre of research excellence on Resilience and Sustainability research, awarded to the same core constellation – CTM, SEI and BI – end of 2005. We intend to start the recruitment of young scientists (PhDs and Post-Docs) during the course of the 2nd year (1-2 PhD student and 1-2 Post-Doc researcher). Our strategy is to prioritize the senior recruitments first, and let the junior research staff follow, in order to secure good supervisory capacity at the Institute.

We foresee that the deputy director will initially be responsible for building the outreach, partnership and capacity building activities. We foresee the need to also appoint an administrative assistant, however not until the latter part of the 1st year. In total, our aim for the 1st year is to establish a small but significant group of 18- 24 staff, of which 6-9 will be new recruitments and the remaining 12-15 originate from existing staff (Table 6.1).

A key emphasis during the establishment of the Institute will be to foster interdisciplinary research, and a broad representation from different disciplinary research backgrounds, and create dynamic research teams that work closely together and share the scientific vision and research approach of the new Institute. This will be achieved through the mixed staffing strategy suggest in Table 1, where a core group of senior, mid-level and junior scientists are hand-picked to the Institute, which are complemented with the recruitment of new positions across all categories of staff (senior, mid-level, junior). We foresee a balance during the 1st *year of approximately 2/3rd handpicked research staff and 1/3rd externally appointed, with a progressively growing share of new recruitment as the Institute establishes itself.*

Over the suggested five year build-up phase (2007-2011) we foresee that the number of staff will increase from 18 – 24 after the initial year, to 50 - 60 staff, which we estimate will correspond to the total number of staff physically working at a fully operational Institute. The number of researchers interacting actively with the Institute will be much larger though, with probably more than 10 visiting scientists per year (Table 1 shows only full person years), close collaboration with researchers at other faculties at Stockholm University, whose positions are not formally tied to the Mistra

Staff category	2007		2008		2009		2010		2011	
	Range		*Range*		*Range*		*Range*		*Range*	
Leadership										
Director	0.5		0.5		0.5		0.5		0.5	
Science Director	0.8		0.8		0.8		0.8		0.8	
Deputy Director	0.5		1		1		1		1	
Administration										
Head admin	1		1		1		1		1	
Assistant	0.5		1		1		1		1	
Support (IT, Reception, others)					1		1		1	
Outreach and Policy										
Outreach and communications officer	0		1		1		1		1	
Senior Researchers										
Professors	1		1	2	2	3	2	3	3	4
Researchers	1	2	2	3	3	4	4	5	5	6
Junior Research positions										
	0	1	1	2	2	3	3	4	3	4
Joint Positions										
SU	3	4	3	4	4	5	4	5	4	5
BI	1	2	1	2	2	2	2	2	2	2
SEI	2	3	2	3	3	4	3	4	3	4
International Partners	1		2	3	3	4	3	4	3	4
Visiting Scientists	1	2	2	3	3	4	3	4	4	5
Young Scientists										
PhDs										
Contributed	3		4		4		5		5	
New	0		1	2	2	3	4	5	5	6
Post-Docs										
Contributed	2		3		3		3		3	
New	0		1	2	2	3	3	4	4	5
	18	24	28	38	39	48	45	54	50	59
New Recruitments	6	9	14	21	22	29	27	34	32	39
Existing staff	12	15	14	17	17	19	18	20	18	20

Institute (> 10 researchers), and close partnership-based research with Swedish and International research institutions, including both young scientists (Phd students and Post-Docs) and researchers (funded through external research projects attached to the Institute).

In total we foresee building an Institute with in the order of 100 researchers attached to it, including Institute staff and affiliated Swedish and international research staff, directly involved in research carried out by the Mistra Institute at any given time once the Institute is fully operational.
PhD and Post-Doc positions will be an important feature of the Institute. In the initial selection of this group, priority will be given to young researchers who already have demonstrated their interest and capacity for independent and creative interdisciplinary research, and who share the scientific vision of the new Institute. These initial PhD students will be part of the existing interdisciplinary PhD-group at CTM to be merged into the new Institute.

All PhD and Post-Doc positions at the Institute will have at least a dual institutional affiliation; the main institutional home at the Mistra Institute, and an affiliation to a research department at Stockholm University or some other department at a Swedish or international university. This is done for both formal and strategic reasons. Formally, to comply with the university regulations for PhD positions, which require a registration at university departments, but particularly from a strategic perspective. We believe it is important that all young researchers at the Mistra Institute also have

an academic affiliation to a university department as a way of assuring a maximum support to research careers (opportunities for faculty positions, teaching, supervision etc.). This arrangement also strengthens the collaborative nature of the Institute.

A number of staffing structures will be established during the start-up phase. In principle we foresee the following main categories of research staff:

- Leadership (Director, Science Director, Deputy Director) appointed by the Vice-Chancellor of Stockholm University.
- Professors, Senior Scientists appointed by Stockholm University, with formal affiliation to a University faculty/department.
- Research positions appointed directly by the Director of the Mistra Institute.
- Joint Positions, either contributed from core partners (SU, BI, SEI) or shared with Swedish and international research partners.
- Visiting scientists, including guest researchers and sabbaticals where costs are shared between the Mistra Institute and the home institution.
- Young scientists, including PhD students and Post-Doc researchers, both categories with dual affiliations to the Mistra Institute and a University faculty/department.

This flexible staffing strategy will enable adaptive solutions, while at the same time securing a strong university connection, quality control, and career consideration. The flexible structure will also allow researchers to have part time or full time employment at either the Institute or the home department, although as a general rule sustained presence in the Institute should be considered standard procedure for most researchers.

During this initial build-up phase we will launch a pioneering plan for academic career opportunities. We intend to initiate a tenure track system for young and mid-career scientists with shared affiliation and employment with relevant university departments (with Post-Doc, researcher, and Assistant Professor positions). Several international exchange programs will be launched, for PhD students and Post-Docs, for visiting researchers (1-3 months) and sabbaticals (6-12 months). An important emphasis will be to develop a strong transdisciplinary group of young researchers. We intend to invest strongly in this group by establishing a Stockholm Mistra Research School on social-ecological systems within the Mistra Institute (SMI Research School). This research school will become a platform for young scientists. The aim is to give young scientists at the Mistra Institute common scientific core principles and values, develop a culture for transdisciplinary research, promote innovative and creative new research, and attract mentoring and science exchange with leading researchers around the world. The Research School will offer course curriculum for PhD and PD researchers, hold seminars, and initiate research activities. Young scientists attached to the school will maintain a formal affiliation to "home" departments at Stockholm University or other universities and may also share affiliation and positions with collaborating international research groups and institutes.

6.6.2 Fully operational phase I: 2009 – 2011 and beyond

As seen from Table 6.1, we are planning for an Institute of approximately 50 – 60 staff once the Institute is fully operational from 2011 onwards. Our vision is that the Mistra Institute will have over 100 researchers engaged in Mistra related research together with partners in Sweden and across the world. Moreover, we plan for the Mistra Institute to be closely embedded in a dynamic interdisciplinary research environment on sustainability oriented research, with a total of > 110 staff under the same roof (Mistra Institute, SEI, CTM, and Albaeco).

In Table 6.1 the leadership construction, with a 50% Director, 80 % Science Director and a full-time Deputy Director is proposed also for a fully operational Institute. As mentioned, we suggest a high degree of flexibility here. The exact model will be agreed upon as the Institute evolves.
It is foreseen that particularly the young scientist programmes will increase in importance once the Institute is in full swing. We intend to develop and widely disseminate the young scholars

program of the Institute around the world. This may result in an even larger growth of PhD and Post-Doc researchers attached to the Institute.

The Institute will put a strong emphasis on evaluating its research direction and performance. The proposed biannual science to policy dialogue of the Institute (the Stockholm Forum on Sustainable Governance), will together with the Panel of Science Advisors (PSA) and the Institute board, function as key tools to adjust and change direction of research endeavours. External evaluations of the research will be carried out, as well as evaluations of the tenure track researchers, and permanent research positions.

6.7 The Stockholm MISTRA Research School on Social-Ecological Systems

As seen from Appendix VII, there already exists an impressive group of young dynamic researchers linked to CTM, BI and SEI, carrying out research across disciplines, scales and geographical locations in the world.

During the initial three years, we intend to gradually build the group of young scientists (including junior research positions, PhD students and Post-Doc researchers). During the 1st year (2007), we will establish a small group of five contributed young scientists, and possibly recruit one young researcher. We have decided to prioritize the establishment of a core group of senior researchers during 2007, and only start recruiting external PhDs and Post-Docs in the 2nd year. During 2008 we estimate adding two contributed researchers, recruiting 1-2 PhDs/PDs and 1-2 young researchers, establishing a young scientists group of 10-13 scientists. We foresee that this group will grow to some 20-23 scientists when the Institute is fully operational.

6.8 Tenure tracks and staff development

Building on the experience from the Beijer Institute and CTM, close mentoring arrangements will be developed between visiting scientists and PhD/Post-Docs, and junior researcher will be given important roles in top levels workshops, the possibility to visit and work with well know research groups and international centres and the opportunity to carry out research and publish with distinguished international scientists. Similarly, based on existing links with a large number of scientific journals (editors, advisory boards, editorial boards) among the lead scientists of the proposed Institute, special thematic publication arrangements will be initiated, where visiting scientists and young Institute researchers are given opportunities to jointly advance thematic research fields and publish them in special issues of high-ranking journals.

We will also explore innovative methods for evaluation and career planning, complementing the traditional ones based on peer-reviewed publications. Such methods include 360^0 feedback, multi-source feedback and multi-rater assessments. These are widely used in knowledge intensive businesses such as in biotechnology, to promote innovation and creativity.

By contributing the experience, knowledge and networks of the three institutes and associated scientists the SMI will become a major attractor for interdisciplinary research on complex social-ecological systems and the continuous exposing of young scientists to forefront research and collaboration will enhance the visibility of the work of the SMI on the international scene.

7 Funding and Budget

The funding strategy for the SMI follows Mistra's instruction of a co-funding in the same order of magnitude as Mistra's own contribution. We have a strong institutional commitment from the Stockholm University, the Beijer Institute, and the Stockholm Environment Institute, on co-funding to the new Institute. Furthermore, we have already at present research grants that will be contributed to the Institute, and are confident of the large potential of this Institute to attract new research funding for projects and programmes.

We present a tentative budget for the years 2007, 2009 and 2011, i.e., for the 1st start-up year, the 3rd year under full Mistra funding, and the 5th year, when we foresee that the Institute will be operating at its full scale.

The budget follows the presented plan for recruitment of research and support staff, and interprets this plan in economic terms. We have put a strong emphasis on securing funding for research personnel, while at the same time guaranteeing economic conditions for a strong leadership, efficient administration and realistic conditions for the planned research. The budgets also show the planned, gradual build up in economic terms.

As we intend to embark on a gradual build up of the Institute, co-funding may not reach the level of the Mistra grant already during 2009, but in the long run, we are confident that the co-funding will reach or exceed the level demanded by Mistra. As seen from the Budget (Table 7.1), we estimate that the co-funding and external research grants will contribute approximately 9 MSEK during the first year (i.e., exceeding the Mistra support of 6 MSEK), and stabilise around 22 MSEK/year after 5 years, i.e., at a parity with the Mistra support of 20 MSEK per year. A reason for the large own contribution already during the 1st year is that the core partners recently received a grant from FORMAS to establish a centre of excellence on resilience and sustainability science of 5 MSEK/year for five years, beginning in 2006. This grant has a research agenda that coincides closely with the intentions of the Mistra invitation (furthermore with a focus on inter-disciplinary training of the next generation of scientists), which makes it a very logical contributed research project to the new Institute.

The Mistra Institute will constitute an attractive recipient of external research grant. This combined with our own experience in generating Swedish and international research funding, will provide a good platform for co-funded external research. Apart from Swedish sources of research funding, we will actively pursue collaboration in relevant EC projects, and research funded from Foundations, donor agencies, development banks and others. We foresee good opportunities for funding under the EU 7th *Framework programme,* which we anticipate will emphasis support to international research networks.

The staff costs have been estimated following the salary policy of Stockholm University, securing attractive but not excessive salaries for the personnel. For the joint positions, we have here calculated that the Mistra Institute normally will cover half the costs, even if the income for these positions some times will come entirely from the cooperating partners.

We find it important that the researchers at the Mistra Institute have excellent possibilities to take part in international research activities, as well as have the possibility to arrange workshops or scientific conferences within the budget of the Institute. We therefore suggest a relatively well funded workshop and travel budget. Furthermore, the planned bi-annual science and policy dialogue (the Stockholm Forum on Sustainable Governance) will require some substantive core-support from the Mistra Institute. The Institute running costs also encompasses costs for computers and computer services.

Income	**2007**	**2009**	**2011**
Mistra	6000	20000	20000
SU	1200	8000	10000
SEI	800	1200	3000
BI	500	800	1000
External research funding	6000	7000	10000
Total income	**14500**	**37000**	**44000**
Expenditures			
OH/VAT costs			
University value-added tax, Mistra	480	1600	1600
OH-costs, SU	1170	3142	3783
Net income	**12850**	**32258**	**38617**
Institute costs			
Leadership,	1,818	2,289	2,289
Administration	876	1,752	1,752
Outreach officer		603	603
Research staff:			
Professors	1000	2000	3000
Senior research positions	750	3000	3750
Junior research pos.	0	1190	1785
Joint positions	2355	3780	3780
PhD	0	760	1900
Post-Doc Researchers	0	1080	2160
Visiting researchers	1000	3000	4000
Staff costs, total sum	***7,799***	***19,454***	***25,019***
Research activities	500	2300	2600
Workshop, travels	800	2100	2300
Offices	1500	2800	3000
Outreach and communications	300	1200	1300
Institute running costs	1250	2900	3100
Contingency	701	1504	1298
Total net costs	**12850**	**32258**	**38617**

Table 7.1. Proposed budget for the Stockholm MISTRA Institute (SMI)

The outreach and communications budget includes costs for publications, policy briefs, information materials, web-site development, etc.. We foresee significant synergies here, particularly during the first years, with the existing outreach and communications work of the core partners and particularly Albaeco.

Overhead costs will be paid to Stockholm University according its general rules, i.e. 18 % of total personnel costs, directly accounted for in the Mistra budget. We have also deducted for University VAT.

8 International Outreach

8.1 Vision and prospects for outreach

Our vision on international outreach is to establish a world-class Institute, recognised (1) for its pioneering and novel research, (2) for the quality, credibility, relevance and independence of its research, (3) for the close interactions between science and society in defining and pursuing research, and (4) for its importance as a knowledge provider for local, national, regional and global policy processes. In short, we intend to develop an Institute that in a prominent way contributes to set the future global agenda on sustainable development.

Our prospects of achieving the vision are presented in the following. We will build on our long experience of outreach, both in terms of interactions with society during the research process, and in terms of communicating research to society.

Participatory approaches, stakeholder involvement in decision processes, and adaptive co-management of complex social-ecological systems, are increasingly seen as fundamental to sustainability. The core partners adhere to the key principle that the research process is an iterative and reciprocal exchange between science and practice, i.e., that research involves mutual learning, continuous exchange with stakeholders, and is based on local ownership.

We therefore define outreach in a broad sense, including this action research approach, as well as policy dialogues, dissemination and communication, i.e., the whole process of bridging science to society. This is an important core feature for the new Mistra Institute – to integrate learning and participation in defining the research agenda and in the research process itself, and to continuously advice society.

Moreover, globalisation and global change connects spatial scales, both in biophysical and social processes, generating inter-dependencies from local to global scales. We have a long experience in bridging our science to society across scales, from local, to the national and regional scales, to global policy processes.

8.2 Advisory roles in global processes

We are engaged in a number of key global processes related to sustainable governance. On behalf of the Swedish government and ICSU, Professor Carl Folke led the work in writing an influencial report on Resilience and Sustainable Development for the WSSD summit in Johannesburg 2002. The report was co-authored and presented at the summit by Johan Rockström. In Sweden, the report later substantially influenced the contents of the government report in 2002, "En samlad naturvårdspolitik" (Skrivelse 2001/02:173), and parliamentary bill on Sweden's environmental goals in 2005 (bill 2004/05:150).

The Beijer Institute has a long history of knowledge support to policy processes, e.g., by providing influential background reports on functional biodiversity to the process that resulted in the Convention for Biodiversity (CBD) at the UNCED meeting in Rio de Janeiro in 1992. Furthermore, BI's research on environmental accounting has had a strong influence on global institutions such as the World Bank.

Together with UNDP and UNEP, SEI is involved in providing integrated analyses for the UN Millennium development processes implementing the Millennium Development Goals, particularly on environmental sustainability. SEI presented a report on water, sanitation and energy requirements to attain the MDGs at the UN Millennium Summit at UN in 2005.

CTM was invited to participate and give a presentation (Prof. Thomas Elmqvist) at the large international meeting "Biodiversity – Science and Governance" organized on the initiative of President Jacque Chirac in Paris 2005. The meeting has resulted in a new initiative, IMoSEB, to strengthen the research component and implementation of CBD and we are involved in the development of this process.

Within the UN-system, Thomas Elmqvist is a member of the UNESCO/MAB ICC, the global governing board that decides on policies and strategies for the World Network of Biosphere reserves.

On climate change, SEI scientists are lead authors of the IPCC, and active participants in the COP process. SEI also has a formal role as advisors to the UNFCCC, and we are involved in several initiatives on climate policy and on capacity building of climate negotiators. The COP 11 meeting in Montreal established SEI as UNEP's new Collaborative Centre on Adaptation to Climate Change. Together with IIED (International Institute for Environment and Development), and IISD (International Institute for Sustainable Development), two policy research institutes on sustainable development, SEI has established a knowledge for policy alliance on climate change in developing countries (the Global Initiative on Climate Change (GICC)).

All three core partners played an important role in the Millennium Ecosystem Assessment. Several scientists at CTM and SEI were lead authors for chapters in Conditions and trends volumes and in the chapters on sub-global assessments where Carl Folke had a coordinating role. SEI, on behalf of the Ministry for Foreign Affairs in Sweden, carried out an analysis in 2005, on environmental sustainability and the Millennium Development Goals, which linked the MA and the UN millennium process.

8.3 Advisory roles in European and national processes

At the European level, we are engaged in a number of policy processes on sustainable development. During the British Presidency of EU 2005, CTM was invited (Prof Thomas Elmqvist) to present recent advances on resilience and vulnerability research to all the national environmental advisory councils in the EU as part of the development of new strategies for actions on biodiversity and climate change within the European Union. In Sweden we are regularly involved in supporting the Swedish government (the Swedish Environmental Advisory Council). Recently we participated in a preparatory analysis on global sustainability and governance, which forms part of a Swedish parliament decision to establish a Commission on global development (facilitated by Siv Näslund, including Carl Folke, Johan Rockström, Karl-Göran Mähler, Thomas Ries of Utrikespolitiska Institutet, Torsten Persson, Will Steffen, former head of IBGP). Furthermore, in 2005 the Swedish Ministry of Environment and Ministry of Defence jointly held a meeting focused on vulnerability and society's response to surprise. CTM was invited to participate in the dialogue and Thomas Elmqvist presented recent research on resilience and vulnerability.

SEI gives regularly support to Sida on resilience, vulnerability and sustainable development within the Swedish development cooperation. Recently, as a response to the Tsunami disaster, SEI took the lead together with KTH and IVL of the Swedish DIRECT initiative (Disaster resilience Centre), aimed at integrating resilience thinking in disaster prevention and reconstruction. Table 8.1 summarizes other important policy processes that SEI, BI and CTM are involved in.

highly relevant for understanding both emergences of adaptive management schemes as well as the outcome of such management policies (Pretty & Ward 2001).

High levels of social capital within a group can under certain circumstances serve to perpetuate power relations, foster distrust against outsiders, impede social and institutional change, and work as an obstacle for implementation of environmental reforms (Lundqvist 2001). Some forms of social capital can have beneficial effects, whereas others might have adverse impacts on the possibility of adopting adaptive

Table 8.1. Other important policy processes on global, regional and national levels in which SEI, BI and CTM are involved

Scale	Process / Network	Role / Activity
Global	The UN Commission for Sustainable Development (CSD) (*SEI*)	Organised official Swedish side-event at CSD 13 on Water and Sanitation in 2005, engaged in the current energy and climate theme
	The UNEP DTIE on sustainable consumption and production (SCP) (*SEI)*	European level policy dialogue as a resource institution
	The UNEP Global Environment Outlook (GEO 4), (*SEI*)	Lead authors on atmosphere, and contributing authors on scenarios. Lead authors on scenarios in GEO3
	The Poverty and Environment Partnership (PEP), a UNDP and UNEP coordinated initiative on environment and poverty alleviation (*SEI*)	Key role in supporting PEPs work on environmental sustainability and the millennium development goals.
	The RING Alliance, a global network of development oriented research institutions and NGOs (*SEI*)	Active member
	Comprehensive Assessment on Water management in Agriculture (*SEI*)	CGIAR led, with FAO and Ramsar Convention as patrons. SEI serves on Steering Committee, and functions as lead authors
Regional	The UN ECE initiative at the European level (UN decade on Sustainable Development Education) (*SEI*)	Resource institution on defining policy and content on training.
	In Asia, SEI has mangy years of collaboration and ongoing engagement with the Asian Development Bank (ADB) on sustainable futures for the Greater Mekong Subregion (GMS).	Research and development partner, and resource institution.
	We are represented on the ADB working group on environment (WGE) of the GMS (*SEI*)	Resource institution
	The Sustainable Development initiatives of European Commission (*SEI*)	Resource institution on sustainable consumption and production policy
	The European Roundtables on SCP (*SEI*)	
	The Townsville declaration on new governance principles for the Great Barrier Reef. (*CTM*)	Generation of key resilience input influencing the direction of the declaration.
National	The Swedish Ministry of Finance - developing green financial indicators for GDP (*BI and SEI*)	
	In China, SEI supports since several years the Swedish contributions to the China Council on International Cooperation on Environment and Development (CCICED), which reports directly to the Chinese Premier, and is managed by the Chinese EPA (SEPA). During 2005, SEI lead a Task Force within the CCICED on sustainable urbanization. (*SEI*)	Science and policy advisor
	The Swedish Ministry for Sustainable Development and Ministry of Foreign Affairs on political processes on sustainable development (*SEI*)	Science and policy advisor
	Advisor to the Regional planning office in Stockholm (RTK) on sustainability related issues (*SEI*)	Science and policy advisor
	SEI gives support to Sida on resilience, vulnerability and sustainable development within the Swedish development cooperation.	Science and policy advisor
	The Beijer Institute, CTM and SEI functions as advisors to civil society organizations, such as the Swedish national association for nature (SNF), the World Wildlife Fund (WWF), and the International Foundation for Science (IFS).	Science and policy advisor

8.4. Local stakeholder processes

The core partners behind the proposed Mistra institute have a long track record of research in partnerships and networks based on stakeholder involvement and local ownership. CTM and the Beijer Institute have ample experience of participatory research at the local scale, where research-

ers and local stakeholders interact during the learning process. This ensures relevance, and enables knowledge generation that can be implemented in local management and governance.

CTM has led a success research partnership with the local county in Kristianstad, in Southern Sweden, where a partnership between science and local management contributed to a process of local resilience building in a social-ecological wetland landscape (Kristianstad Vattenrike) and the establishment of a Man and Biosphere area in 2005. This successful case of adaptive co-management was included in the subglobal assessments of the Millennium Ecosystem Assessment (MA).

SEI has applied many different approaches and techniques (e.g. PRA, stakeholder dialogues, focus groups, policy exercises, GIS-P, individualised marketing, etc.) and these are often influenced by issues such as context, culture, politics and donor requirements. Local action research projects are (or have recently been) carried out with communities in Burkina Faso, Benin, Kenya, Tanzania, South Africa, Zimbabwe, Vietnam, Bangladesh, Sri Lanka, and China. CTM together with researchers at SEI are involved in participatory action research in two river basins in Southern Africa (in Tanzania and South Africa), in a research programme on water, agriculture and resilience building (the SSI programme).

8.5. Dissemination and awareness creation

Outreach also includes dissemination of knowledge to society and awareness creation. We see this task as part of the research process, and have a strong commitment to the communication of science to society. Carl Folke was the pioneer behind Albaeco, driven by the conviction of the need to funnel inter-disciplinary sustainability research to society at large. CTM, BI and SEI have all long-standing experience of disseminating research through capacity building, lectures, popular texts, policy briefs, media and dialogues. Albaeco's newsletter "Sustainable Development Update" (SDU), reaches development donors and companies around the world. We find media interactions as an important responsibility, and invest much effort on newspaper articles, radio and TV films. A particular achievement was the recently developed MANNA exhibition, on the links between food production and ecosystem services, which after a tour in Sweden will be disseminated abroad.

8.6. A plan for International Outreach

As presented in the organisation plan for the Institute, we intend to integrate outreach with the research process. Here we present the four main thrusts of an ambitious international outreach plan, including:

(1) Setting the global agenda on sustainable development
(2) Stakeholder involvement in research process
(3) Setting regional, national and local agendas

As presented in the organisation plan, we intend to invest in a strong outreach capacity at the Mistra Institute (with a full-time outreach officer), and tap synergies with ongoing outreach activities at BI, CTM, SEI and Albaeco. We have developed a tentative communications plan to support the outreach thrusts, which is presented in Appendix VI.

8.6.1.The Stockholm Mistra Institute and global processes

In our vision of building SMI to become an important actor on the global policy arena we will concentrate our efforts on two major initiatives:

The Stockholm Global Forum on Sustainable Governance

We believe the Mistra Institute, through its mission, global network, and high quality science, will develop a very significant global convening power. An important part of our strategic vision of the Mistra Institute is therefore to host a bi-annual high-level Global Forum on challenges for sustainable governance. The purpose of this meeting is to create a platform where political leaders,

heads of industry, representatives for civil society and top scientists will meet bi-annually and discuss the wider directions of world development towards sustainable governance and management of social-ecological systems. The Stockholm Global Forum will also be important in testing the relevance of the research at the Institute, and to guide strategic and novel research directions.

The implementation of the Millennium Ecosystem Assessment
We are currently involved in the process of taking the Millennium Ecosystem Assessment (MA) into the policy and implementation domain. There is a great potential of linking this important process directly to SMI since both the implementation and coordination of still ongoing subglobal assessments of the MA is considered to be further developed and hosted within DIVERSITAS with support from ICSU and UNESCO. DIVERSITAS has recently expressed serious interest in moving its International Project Office for bioSUSTAINABILITY to Stockholm and potentially integrate the IPO with the SMI from 2008 and onwards. There are multiple added values of this, since SMI then would be directly involved in implementation of the Millennium Ecosystem Assessment and coordination of the subglobal assessments. In addition, hosting the IPO would mean additional links to global policy areanas since DIVERSITAS provides a direct route for input into the current IMoSEB processes linked to CBD, and further active links to the Earth System Science Partnership (ESSP).

In addition, over the first five years of the Institute, we will prioritize outreach to a sub-set of processes and bodies that we have identified as particularly relevant for the mission of the Mistra Institute:

- the UN Commission for Sustainable Development and the Johannesburg Plan of Implementation (JPOI) from the WSSD
- the Millennium Development Process (implementation of the MDGs)
- UN Conventions, particularly UNFCCC and CBD
- the Swedish politics for sustainable development and the politics for global development (PGU)

In 2012, when the Mistra Institute is in full operation after its first five years of existence, we foresee that the next UN summit on sustainable development will be held (Rio + 20). This will be an important policy milestone for the Institute, and we set the objective for SMI to be influence in setting the agenda for that meeting. On a closer horizon, CTM, together with BI and SEI are centrally placed in organising a large scientific conference in Stockholm 2008 together with the Resilience Alliance, on resilience and sustainability. This will constitute another important scientific and policy platform for the institute.

8.6.2. SMI and the private sector
The private sector plays a determining role behind processes of change, and in the outcome of governance frameworks. We have a significant experience from interactions with industry and private sector organisations on issues related to sustainable development. Albaeco is currently in the process of initiating a sustainability labelling of industry (Guide Eco), and SEI has experience from renewable energy and scenarios research with private sector involvement. The Beijer Institute, together with the Stockholm School of Economics, the World Wildlife Fund (WWF) and the Swedish Association of Environmental Managers (NMC), has organised modular courses for the private sector on "Business and Global Change – Threats, Opportunities and Added Value". Together with the World Business Council for Sustainable Devleopment (WBCSD), SEI has provided expertise on issues related to water, climate change and scenarios. We intend to engage with industry and organisations such as the WBCSD in the outreach work of the Mistra Institute. The private sector will be an important stakeholder at the bi-annual Stockholm Global Forum of the Institute.

8.6.3. Setting regional, national and local agendas
We will continue to develop our research and policy networks, in order to translate the significant knowledge platform that exists and that we are connected to (see above) into even stronger waves

of knowledge development and communication (see further details in Communication Plan.

We foresee that the Mistra Institute will organise forums for dialogue with policymakers and other stakeholders at the regional, national and local scales. Innovations workshops can be held with different stakeholders, as a way to advancing understanding and defining new agendas. We will build strong media relations in Sweden and internationally, and communicate through a broad spectrum of communications channels, of which several are unique in the scientific world. Importantly, the Institute will adapt and respond to occurrences in the world; commenting, advising and initiating relevant projects, as social-ecological occurrences unfold. We will collaborate closely with important international, national and local organisations, not only research institutions but also governmental organisations and NGOs. We will provide stakeholders with news, analyses and policy advice on a regular basis, and be pro-active in anticipating emerging needs of policymakers and other stakeholders in relation to our field of research.

8.6.4. Stakeholder involvement in research process

We will continue our adaptive and co-management based research approach, and further advance methods of how to link participatory processes, innovations in management and governance, with understanding of cross-scale dynamics of social-ecological systems. This is a pioneering research effort, of how to integrate complex dynamics of SES's in stakeholder processes and in defining governance and management trajectories. We foresee that it will form a back-bone of research across scales, from the local level within the research themes, to the emerging research on international relations and ecosystem dynamics.

A key outreach factor within the research process, will be to establish a culture of stakeholder dialogues, in order to generate relevant and demand driven research at the very front of sustainability science and integrative research on ecological and social systems

8.6.5. Publications strategy

Our publications strategy will focus on high quality science and policy communication.
Publishing high-quality peer-reviewed research in international journals will be at the core of the Mistra Institute. This is not only important for the credibility and reputation of the Institute, but also a key strategy for career development among young scientists. We will stimulate young scientists to take the lead in publishing research, and we will take initiatives to open doors for international inter-disciplinary publications (e.g., through special issues of journals). We have a strong track-record of publishing in high-ranking international journals (e.g., in Nature, Science, PNAS and others), and inter-disciplinary publication (e.g., through Ecology and Society, where Carl Folke is co-editor in Chief,). The Beijer Institute initiated and supports the Journal, Environment and Development Economics (EDE), published by Cambridge University Press.

On policy outreach, we will invest in developing a high-quality and relevant electronic policy newsletter, where key research from the Mistra Institute is translated to policy relevant messages, and communicated on a regular basis to key stakeholders around the world.

8.6.6. Capacity building and awareness creation

Capacity building and awareness creation will be an important part of the outreach strategy of the Institute.

Research capacity building will be carried out within our proposed Research School for young scientists. Beyond this we intend to explore the possibilities of taking the initiative for research capacity building programmes in developing countries. SEI has a long experience of PhD capacity building on genetic resources and biotechnology in East Africa (through the BioEarn programme supported by Sida). Together with START (the capacity building programme on global change within the ICSU family), SEI is currently exploring the possibilities of launching a new research

capacity building and training programme on global change in Africa and South-east Asia. Similarly, the Beijer Institute runs a PhD program in environmental economics, together with the Environmental Economics Unit (EEU), at Göteborg University, supported by the Swedish International Development Cooperation Agency (Sida). Stockholm University also has a leading role in TBA, the Tropical Biology Association, which since 1994 runs month-long courses for African and European students in management and conservation of tropical biodiversity in Uganda, Kenya, Tanzania and Madagascar.

We believe the Mistra Institute will offer an excellent opportunity for wider training of the next generation through short courses, both academic courses and courses for decision makers and managers.