DRAFT for review and comment

Knowledge, Learning, and Societal Change: Finding Paths to a Sustainable Future

Science Plan for a cross-cutting core project of the International Human Dimensions Programme on Global Environmental Change (IHDP)

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Executive Summary

The world is facing unprecedented challenges in sustaining society and managing the global ecosystems on which it depends more sustainably. The Inter-governmental Panel on Climate Change warns that we are on a path of rapid global warming that is likely to result in major and possibly severe disruptions to the existing climate system. While there is a growing body of "hard" knowledge about climate change and other sustainability challenges, and there are technical and economic solutions proposed or in development, there is a wide gap between what we know about these problems and what we – as individuals, communities, organizations, institutions, and governments - are doing about them. One part of the existential challenge of our anthropogenic age is in understanding the causes and effects of Earth system changes to the ecological, geo-physical, social, and economic conditions on Earth on multiple temporal and spatial scales. A second vital part is to enable adaptation to changing conditions and effect a transition to a sustainable societal system. Understanding the first part of the challenge is not sufficient in and of itself to enable the second part. Addressing the second part of the challenge is the task that this project will take on.

The Knowledge, Learning, and Societal Change (KLSC) project of the International Human Dimensions Programme on Global Environmental Change (IHDP) aims to better understand and explain the interplay between actions, knowledge, and learning, so that steps can be taken to help societies move in more sustainable directions.

The mission of the KLSC project is to contribute toward building a sustainable future by identifying, understanding, and enabling the effective use of the mechanisms and levers of behavioral and societal change and adaptation that are linked with knowledge production and learning processes. This will be done through the combined efforts of a collaborative community of researchers, practitioners, and stakeholders working at multiple temporal and spatial scales. The project will focus on the issues of addressing climate change, stemming biodiversity loss, and increasing equity in resource allocation.

Understanding the complex mechanisms, dynamics and outcomes of the interplay between knowledge, learning, and societal change will be crucial in guiding optimal policies and societal adaptation developing a more sustainable global system.

These connections, relationships, and interplay occur at all levels and scales of association in society – individual, community, institutional, regional, and global - which influence the drivers and barriers to societal change and adaptation in relation to knowledge and learning. The KLSC initiative focuses on these complex connections and relationships.

The challenge before the KLSC initiative is thus not only to gain better insight into the connections between our body of knowledge, learning and societal change, but also in how to bring such insights to bear in the real world. To do this, KLSC includes rigorous scholarship yielding deeper insights, action research involving practitioners and stakeholders to develop successful strategies for fostering behavioral changes to sustainable practices across temporal and

geographical scales, and science-society-policy dialogues - including use of new social media - to better understand and support the integration of knowledge and practice with policy.

This combined goal can only be reached by involving a broadly based community in the project. The project will create a collaborative community of people from the sciences, humanities, and social practice, including participation in knowledge production by those living in key affected localities. This wider community – the operational basis for the conduct of this project - is essential in pursuing the research goals of KLSC and applying the emerging understanding to catalyze the transition to a sustainable future for society. Thus at the core of the project is the generation of a new community of research, action, and reflection leading to more sustainable practice in society.

Insights and activities for societal change and adaptation are at the heart of the project. However, to become a successful addition to the existing epistemic, learning, and operational communities in the world, it is of utmost importance that the community that develops around the project becomes the forum where people from the social and natural sciences, humanities, and stakeholders meet, develop a common working language, and compare approaches, theories, and empirical results in order to enhance learning on how to better design and implement change processes for sustainable development.

The KLSC project will become a platform for enhanced learning among diverse stakeholders on how to better design change processes for sustainable development. It will also be responsible for capacity building workshop, sustained mentoring, and support for grant writing for those scientists from developing countries who are interested in research and activities under the KLSC framework.

As outlined in this document, we take a broad view of the concepts knowledge, learning and societal change (chapter 2). Starting from the existing understanding in the literature, we have generated a number of hypotheses on the reasons why behavioral change through knowledge and learning does or does not happen, and on factors that determine those processes. Likewise, a number of hypotheses were formulated on reasons why scaling up to societal or large-scale changes does or does not happen (chapter 3). These hypotheses are the starting points for analyzing case studies and field experiments and therefore are the link to existing scientific understandings on knowledge, learning, and societal change. Chapter 4 describes plans for implementation and community building and the expected outcomes and milestones.

1 Introduction

1.1 The Challenge and Motivation for KLSC

Humanity is facing immense challenges in finding its way toward a sustainable future. One part of the existential challenge of our anthropogenic age is in understanding the causes and effects of Earth system changes to the ecological, geo-physical, social, and economic conditions on Earth on multiple temporal and spatial scales. A second vital part is to enable adaptation to changing conditions and effect a transition to a sustainable societal system. Understanding the first part of the challenge is not sufficient in and of itself to enable the second part. Addressing the second part of the challenge is the task that the KLSC project will take on.

The task of KLSC is a critical part of the global change research effort, which is responding to a clear and present danger to our society and the planet. Despite, and in some ways because of, decades of tremendous progress in science and engineering, our planet's natural system is being pushed to its limits. Yet human society has still to learn how to manage itself in ways that do not threaten the global ecological systems upon which we depend now and in the future. Human influence on the earth system is now so extensive that it is impacting natural systems across the globe. There is evidence that human activity is generating changes to the ecological and climatic systems on which plant and animal life depends that extends well beyond natural variability – in some cases alarmingly so - and at rates that continue to accelerate (Biermann, et al., 2009, Steffen, et al. 2004).

The Intergovernmental Panel on Climate Change (IPCC), for example, warns that we are on a path of rapid global warming that is likely to result in major, and possibly severe disruptions, to the existing climate system. The possible consequences include sea level rise, increased water stress in different regions, desertification, shifts in weather patterns, more frequent occurrence of extreme weather events, and the concurrent human-centered problems these changes are likely to cause: hunger, starvation, loss of life, disease, greater conflict over limited resources with inequitable distribution, and involuntary migration. These changes are also likely to trigger mass biological extinctions, with large numbers of species of plants and animals being lost annually and resulting in some predictable and many unknown impacts.

Our knowledge of the natural science aspects of global change continues to develop rapidly and technology continues to promise more potential solutions to some of the problems. Crucially, a greater recognition recently is emerging of the need for and contributions of trans-disciplinary research that integrates social, institutional, and economic aspects of global change issues with natural science and technology insights.

A specific and critical lack in our quest for a more sustainable world is a sufficient understanding of the interplay between knowledge and learning on one hand and individual behaviors and societal changes on the other. We are all familiar with

examples of knowing something and choosing to act in accord or counter to the relevant knowledge we possess. There are also many examples of diverging micro-motives and macro-outcomes (Schelling 1978). Individual behaviors which in isolation may be considered reasonable and may be inoffensive, but pose significant risks when the individuals interact and the collective action is amplified. A deeper understanding of the interplay between knowledge, learning, and societal change is essential in our learning to adapt to continually changing conditions and moving effectively to sustainability in diverse cultures and across multiple scales of space and time.

For the past decade, knowledge has been seen as a crucial ingredient in achieving the goals of sustainable development. Both the technical progress of the digital revolutions and the increased economic importance of intangible goods in the knowledge society fostered the vision of developing countries leap-frogging whole stages of economic development. Similarly, initiatives based on knowledge holds major implications for transitions towards more sustainable societies. Tremendous progress has been made in terms of lifting millions out of poverty, yet billions of people are still living in abject poverty without adequate access to essential resources and no chance to improve their condition substantially. Equally important, the unequal distribution of wealth, opportunities and risks within societies and regions, and the subsequent unequal distribution of cost and benefits of 'improvements', create major political conflicts that have not received sufficient scientific attention so far.

The first decade of global change research focused on understanding the interaction of the human actions and environmental responses. In the context of natural sciences, the changes triggered by human action led to the development of the anthropocene paradigm, the view that human action fundamentally alters parameters of global natural systems. In the second decade, the social science programs focused on environmental changes and human responses to such changes. It has been well researched how human behavior affects the environment, and we also observe that environmental change does change human behavior. However, the levers and mechanisms of behavioral changes in response to societal contexts are largely unclear.

As research on global environmental change enters its third decade, the insights generated by the first decades have begun to penetrate the public consciousness in some parts of the world. The rising level of risk and the responses that will be required in the future give rise to urgent calls for immediate and long-term action. To enact the requisite behavioral changes across the world's communities and institutions a collaborative effort by individuals, communities, nations, and the international community as a whole is proposed as inevitable course of action (Kaufmann and Gutscher 2001).

However, many thorny questions remain regarding not only what actions to take, but how to motivate and empower action by sufficient numbers of people with very different political and economic perspectives, ecological and physical conditions, and cultures. Many questions of the relationship between the possible actions to take based on current knowledge and the positive and negative, anticipated or unintended consequences of those actions remain unresolved and lead to contested knowledge, ambiguity, and uncertainty. Different individuals or societies may actually believe that they are already pursuing the 'correct' path to

sustainability and thus resist certain actions or changes, while others interpret failing international negotiations as lacking the political will to act.

Actions currently underway and taking shape in response to global environmental change involve all sectors of society: the polity, science, technology, corporate, NGOs, and communities. Activities implemented or in planning range from all types of policy instruments – command and control, economic, service and infrastructure, to communication mechanisms and participatory forums. However, the determinants of human behavior, its motivation, the question if and how our knowledge about change processes interacts with related behavior is the least understood issue in the whole process. But thus far, the scale and impact of these efforts is far too limited in scale and impact in comparison to the challenge before us.

Anecdotal evidence on such activities is wide-spread, while reliable success evaluation connecting activities amongst each other or to meta-criteria is rare. There is little information assessing to which degree initiatives are informed, constructive, and adaptive in the transition to a sustainable society. Validation mechanisms for knowledge-based initiatives for sustainability need to be developed and incorporated in projects to improve on this record, yet they are hard to conceptualize as positions remain torn between global policy issues and specialized case studies. This points to a wide-spread disconnect between knowledge and action in adapting to environmental change. We need focused research and critical, reflective thinking that helps understand the enablers and inhibitors of change to sustainable practices and helps avoid mistakes where efforts and actions in one direction unintentionally undermine initiatives in another.

One example may highlight the need for a substantive large-scale research endeavor in this area: Economic models are the most formalized, well-accepted and practically relevant scientific tools in political decision making, for example in steering financial markets. By nature, such models are based on assumptions about human behavior. As in previous financial crises, the recent one that reached public attention in 2008 revealed the flaws in the theories in use at the time, as no model conclusively predicted or explained the full extent of the crisis. Nevertheless, economic tools are introduced and used for better environmental governance, e.g. in the establishment of emission markets or in the valuation of ecosystem services for international compensation schemes. Therefore, a deeper understanding of human behavior informing and improving economic models will be crucial to avoid politically-induced distortions or blind business as usual responses to crises with their attendant devastating consequences.

Concerns in the (social) scientific community about the effectiveness of the interaction between science and policy led to an initial impetus for developing cross-cutting research on knowledge and societal change. This concern has been voiced within the International Human Dimensions Programme on Global Environmental Change (IHDP, see e.g. Young et al., 2008, p. 261) of which this initiative is a part. The concern is, however, much wider among social scientists worldwide (Jasanoff & Wynne 1998, Haas and McCabe, 2001, Siebenhüner 2002, Jasanoff 2004, Bolin 2007).

Out of the considerations above, this new IHDP initiative on Knowledge, Learning and Societal Change (KLSC) emerged. KLSC can be seen as an examination of the critical enablers and obstacles to adaptation coupled to the use of the new understanding to catalyze adaptation to global environmental change. The KLSC project requires an integrated approach that combines theory, practice, policy, and public participation in understanding and supporting adaptation based on knowledge and learning (see Patwardhan, et. al., 2009).

In this science plan for the IHDP cross-cutting core project, Knowledge, Learning, and Societal Change: Adapting For A Sustainable Future (KLSC), three themes have been chosen as examples of global change. They are mitigating and adapting with climate change, stemming biodiversity loss, and increasing the equity of resource allocations. Understanding the interplay of knowledge, learning, and societal change within each of these themes is of tremendous importance in its own right, but choosing these three themes is also intended to narrow the focus to create a critical mass of work on each theme and to allow comparisons between the insights gleaned from case studies and activities tied to each theme.

1.2 KLSC in the Context of Global Change Research

The fundamental importance of this project about knowledge and action is evident in reviewing how it permeates the frameworks supporting both the broadest current effort to change the conditions in which humans live - the Millennium Development Goals (MDGs) - and the core challenges in addressing global environmental change research as formulated in the ICSU[1] Visioning process and the Belmont Challenge undertaken by ICSU at the request of the Belmont Forum of IGFA[2].

The ICSU Visioning process sets out a guiding framework for global change research over the next decade with five Grand Challenges. The criteria for selection of the Grand Challenges were scientific importance, global coordination, relevance to decision makers, leverage to help in addressing multiple problems and other global change challenges.

In the priority research questions posed under each of these challenges, several stand out as examples of the questions that KLSC is particularly well suited to address. These are flagged in the italicized (added) portions below.

The five Grand Challenges (ICSU 2010) and the priority research questions of particular relevance to KLSC are:

1) Forecasting: Improve the usefulness of forecasts of future environmental conditions and their consequences for people

[1] International Council for Science

2 International Group of Funding Agencies for Global Change Research

2) Observing: Develop, enhance, and integrate the observation systems needed to manage global and regional environmental change.

3) Confining: Determine how to anticipate, recognize, avoid, and manage disruptive global environmental change.
   - Which aspects of the coupled social-environmental system pose significant risks of positive feedback with harmful consequences?
   - How can we identify, analyze and track our proximity to thresholds and discontinuities in coupled social-environmental systems? When can thresholds not be determined?
   - *What strategies for avoidance, adaptation and transformation are effective for coping* with abrupt changes, including massive cascading environmental shocks?
   - *How can improved scientific knowledge of the risks of global change and options for response most effectively catalyze and support appropriate actions by citizens and decision-makers*?

4) Responding: Determine what institutional, economic, and behavioral changes can enable effective steps toward global sustainability.
   - What institutions and organizational structures are effective in balancing the trade-offs inherent in social-environmental systems at and across local, regional and global scales and how can they be achieved?
   - What changes in economic systems would contribute most to improving global sustainability, in the context of global environmental change, and how could they be achieved?
   - What changes in behavior or lifestyle, if adopted by multiple societies, would contribute most to improving global sustainability, in the context of global environmental change, and how could they be achieved?
   - How can institutional arrangements prioritize and mobilize resources to alleviate poverty, address social injustice and meet development needs under rapidly changing and diverse local environmental conditions and growing pressures on the global environment?
   - How can the need to curb global environmental change be integrated with the demands of other inter-connected global policy challenges, particularly those related to poverty, conflict, justice and human security?
   - How can effective, legitimate, accountable and just, collective environmental solutions be mobilized at multiple scales? What is needed to catalyze the adoption of appropriate institutional, economic or behavioral changes?

5) Innovating: Encourage innovation (coupled with sound mechanisms for evaluation) in developing technological, policy, and social responses to achieve global sustainability.
   - What incentives are needed to strengthen systems for technology, policy and institutional innovation to respond to global environmental change and what good models exist?

- How can pressing needs for innovation and evaluation be met in the following key sectors?
- How can global energy security be provided entirely by sources that are renewable and that have neutral impacts on other aspects of global sustainability, and in what time frame?
- How can competing demands for scarce land and water be met over the next half century while dramatically reducing land-use greenhouse gas emissions, protecting biodiversity, and maintaining or enhancing other ecosystem services?
- How can ecosystem services meet the needs for improving the lives of the world's poorest peoples and those of developing regions (such as safe drinking water and waste disposal, food security and increased energy use) within a framework of global sustainability?
- What changes in communication patterns are needed to increase feedback and learning processes to increase the capacity of citizens and officials, as well as to provide rapid and effective feedback to scientists regarding the applicability and reliability of broad findings and theoretical insights to what is observed in the field?
- What are the potentials and risks of geo-engineering strategies to address climate change, and what local to global institutional arrangements would be needed to oversee them, if implemented?

The Visioning document, in its list of deliverables, includes the following that is of particular note for KLSC:

New methods for doing research (involving innovation in synthetic research approaches, participatory practices, and collaborations) and communicating results, in which stakeholders are empowered, informed, and motivated through the research process to take effective action. (All Challenges).

The overarching view of KLSC is using knowledge and learning to change to adaptive and sustainable practices. That is the research framework for KLSC and is more than the forecasting and response framework articulated in the Grand Challenges document.

The Belmont Challenge states that "The objective is to develop and deliver knowledge in support of national and international government action to mitigate and adapt to global and regional environmental change and its associated regional hazards." This immediately raises the point that it is insufficient to 'develop and deliver knowledge" as a packaged commodity. The crucial components of locally appropriate processes of developing knowledge, learning to understand it, and engaging stakeholders to use their understanding to support and catalyze action are the core issues for KLSC.

Adding to the relevant parts of the ICSU Visioning document are the following sections taken from the Belmont Challenge. Again, the portions particularly germane to KLSC are italicized:

Broad societal issues for the Belmont Challenge:

"A key challenge is to understand the roots of human behavior as it pertains to human-environment interactions. It is important to understand how and when major behavioral changes occur.

Within this framework, some of the focus should be on:

1) top-down approaches featuring public policy making and implementation;

2) bottom-up approaches featuring the role of social movements;

3) the role of institutions and, more specifically, governance systems;

4) decision-making under uncertainty, including the roles of rules of thumb and heuristics (educated guess, intuitive judgment or common sense) and the role of local or traditional knowledge, as well as religious or spiritual beliefs; and

5) human security, specifically options available to individuals and communities to stop, to mitigate or to adapt to environmental change and related social vulnerabilities, and their capacities to do so."

The fundamental importance of a review of our knowledge and our knowledge about knowledge and action becomes clear in reviewing how it permeates the frameworks supporting both the biggest current effort to change the conditions in which humans live (the MDGs) and the challenges addressing the parameters of Global Environament Change (Visioning and Belmont)

1.3 Mission and Objectives

The mission of the KLSC project is to contribute toward building a sustainable future by identifying and understanding levers of behavioral and societal change that are linked with knowledge and learning, and to support closing the gap between knowledge, societal learning and action and leading to change for sustainability. This will be done through the combined efforts of a collaborative community of researchers, practitioners, and stakeholders working at multiple temporal and spatial scales.

Objectives:

- The KLSC project will *contribute to Global Change research* by its specific perspective on societal adaptation to global change and a specific set of questions focused on climate change, stemming biodiversity loss, and increasing equity in resource allocation.

- KLSC will *contribute to the social sciences* in general by enhancing concepts of the production of knowledge, the links between learning and behavior, and the relationship between individual decisions and collective change processes. In particular, KLSC will broaden the perspective to investigate the uses of knowledge, thus going beyond the traditional study of the subject.

- KLSC will *contribute to the integration of disciplines*, including the integration of natural and social sciences, by giving priority to assessing and integrating existing stock of research through examining the influence and interplay of knowledge, learning, and change. In particular, investigation the framing, perception and use of scientific knowledge will support the link of natural science findings to the processes at the heart of social science research.

- KLSC will *contribute to theory-practice integration* by focusing on the valuing and use of knowledge on the one hand and the connection of knowledge as a tool to address societal needs on the other hand. Given the urgency and complexity of challenges such as climate change, biodiversity loss, resource limitations, and other sustainability issues, the KLSC initiative will foster science-policy-society interactions as an integral part of the research project and which are framed by the project's research findings and at the same time contribute to them.

- Finally, KLSC will generate *impacts beyond science*. Aside from its contribution to some of the most pressing questions of our time, in the trajectory of this project, successful implementation should also be sought after in research and education. Insights generated in the project should lead to shifts in research agendas, based upon the insights generated through the project. It should also lead to shifts in both formal and informal (i.e., schools on one hand and museums, science centers, zoos, aquaria, after-school programs, on the other hand) educational practice and educational systems, because it is likely that the need for different knowledge and different core competences will become clearer.

The research questions are further elaborated upon in chapters 2, 3 and 4. In chapter 2 they are addressed from the perspective of the existing scientific literature on knowledge, learning, and societal change. Chapter 3 formulates research questions on the relationship between knowledge, learning and societal change, which can be considered starting points for the project. Chapter 4 lays out the plan for the project and its deliverables and desired outcomes.

2 Background and State-of the Art

2.1 Societal Adaptation to Global Change

The ICSU visioning process notes that the primary product for the next decade of global change research is "the knowledge base needed to support efforts to achieve sustainable development in the context of global environmental change". This objective provides the underlying question for the KLSC project: How does knowledge influence and support decisions and actions contributing to such efforts of sustainable development and the necessary societal changes?

Societies are constantly changing. Changes are caused by a variety of reasons ranging from natural processes such as the replacement of its members through generations or changes in the surrounding environment, to decisions about where to live and how to behave towards each other, to active efforts to improve the functioning of society. The latter are a special case, as they are based on predictions and visions about how societies should look like, visions that evolve with leaders, activists and the general population learning. Social change processes observed ultimately reflect a sum of myriad individual learning processes and behavioral adjustments from which societal trajectories emerge.

Learning also occurs in a variety of ways and settings, formal and informal, as individuals and as groups, consciously and unconsciously. Everyday occurrences and experiences teach us practical knowledge, and a lot of effort is invested by most societies in teaching its members shared conventions such as language or script. Interaction with and reaction to the environment plays a crucial part in everyday learning as, for example, when people learn from a large-scale disaster like a tsunami to run when the ocean recedes. Learning also includes active reflection on experiences to integrate them with the existing stock of knowledge in a society, drawing conclusions or generalizations from patterns, and generating predictions and expectations.

Tapping into existing knowledge is deeply ingrained into the human consciousness and forms a building block of our social nature. Knowledge is shared and transferred, forming mankind's collective memory. This collective knowledge is constantly increasing, as people share their observations, as media report events, as professionals or volunteers document patterns they discover in the 'practical empirics' of their work, and not least as the scientific community catalogs observations following specific conventions of design and documentation.

Societal adaptation to perceived external risks or threats occurs through the interplay of all three sets of processes: production of knowledge on current and anticipated conditions and ideas for change, societally distributed understanding of the implications of changes in conditions and reflective use of this knowledge in individual and collective learning processes leading to conscious actions towards societal change that aims to sustain and secure the society in the future.

The following sections provide a background and a perspective for KLSC on the knowledge production, learning processes, and societal change.

2.2 Knowledge Production and Knowledge for Sustainability

The nature of knowledge, its representation and transferability, as well as the social value and effect of education has been subject of philosophical debates for thousands of years. Among the oldest written records known to mankind are the Egyptian "wisdom books", passing on the lifetime experiences of fathers to their sons. Education, pedagogy, and didactics are fields specifically dedicated to investigating the process of learning to acquire and use knowledge to shape behavior and societies. The research in these fields is based on psychological foundations laid over more than a century. The challenge in researching knowledge for societal change is not first and foremost the definition and description of unexplored theoretical grounds, but the selection, combination, and integration of the range of existing theories to shape the framework of KLSC.

Some important classifications and distinctions of knowledge are widely used. From the earliest attempts at a theory of knowledge, epistemology, concerned with the nature, varieties, origins, objects and limits of knowledge, philosophical schools split between rationalists like Plato and Descartes, who based knowledge on reason and reasoning, and empiricists such as Aristotle and Locke, who focused on individual experience. Leibnitz and Hume established the fundamental distinction between analytical knowledge and empirical knowledge, a separation with persistent impact on education and scientific understanding to this day. Today, theories of knowledge often focus on typologies and classification, most prominently that of tacit (or procedural) versus explicit knowledge. Michael Polanyi [1962] pioneered this distinction as a problem in the philosophy of science, which proved important to understand, amongst others, difficulties in the transfer of technology or institutions. In a similar vein, Zollo and Winter (2002) distinguish between different kinds of knowledge. These include factual knowledge (knowing what), procedural knowledge (knowing how), and normative knowledge (knowing why).

A classification starting from the kind of 'storage' distinguishes (1) symbolically expressed knowledge (media), (2) embodied knowledge, (3) embrained knowledge and (4) encultured knowledge (of social collectives) (McGinn 2001). The existence of encultured knowledge points to the fact that not only individuals, but also collectives can hold knowledge.

In other disciplinary perspectives, knowledge is seen in a broader perspective. It includes different types of knowledge that in psychological models and empirical studies are treated as separate components. First, there is systemic understanding of the problems at hand (current state knowledge). Second, individuals need knowledge about sensible targets that are considered of sufficient worth to be pursued (target state knowledge). Third, effective action requires the knowledge about behavioral options to achieve the goals and about the efficiency of these options regarding their ecological and social impacts (transformation knowledge). Such categorizations offer a view of knowledge as a particular part of a process of sense-making, followed in a business management perspective by Ackoff (1989) amongst others, and thus relevant to decision making.

Reflecting this vast historic background and current political context, the KLSC project embraces a broad notion of knowledge that goes beyond a narrow notion of cognitive, science-based forms of knowing. Knowledge is approached in its sense as a resource in all its forms, that feeds into learning processes, attitudes and actions. In this sense, knowledge can be conceptualized as any form of mental representation of the world, including explicit and tacit knowledge, academic (e.g. scientific journals, reports) and non-academic, local, and traditional (indigenous, cultural, religious), cognitive, procedural, and experiential forms. In the context of this project, re-visiting the status of research regarding the structure and nature of knowledge serves only as a tool, leading to the core issues: the production and use of knowledge, its interplay with action, and its role in societal change.

The terms data, information and knowledge are used interchangeably and in a wide variety of combinations, with innumerable popular, scientific and philosophical definitions. Making the different notions of knowledge accessible and develop a shared epistemology and language will form one core challenge of the project activities.

The term Data describes a coded expression of an observation or sensory input, and means a statement accepted at face value. The definition of 'accepted' statements points to one characteristic relevant to the project, namely that all data include some social conventions. Data can be depersonalized and coded, it can be gathered, transferred, or stored, but it remains connected to a social context. The form and manner in which knowledge is presented is not in itself an issue for KLSC. What does enter is how different media mediate the message to affect the perception and decisions for or against behavior change. An example is the debate that has raged as to how much media space should be given to competing climate change positions. What is meant by fair access and coverage in the media? This tension between evidence-based reporting and "balanced" reporting has been studied and discussed by many in the context of the role of media in influencing perceptions (Burgess, 1991; Dunwoody 2007; Jacques 2009: Jacques, Dunlap, Freeman 2008, Grundmann 2007). The question for KLSC is how that coverage ultimately affects changes in attitude and behavior by the users of the media.

Information has no widely accepted definition. The term became omnipresent in the context of today's "Information Technology"-infused world, but the variety of its meanings encourages inflationary use. However, 'information' is essentially more than data: it has a *context* that gives data additional meaning and allows a practice-related interpretation. This effect can be illustrated with a simple sentence: 'The notes were sour because the seams split.' Chances are that this statement consisting of simple and familiar words is confusing unless the reader is asked to think of a bagpipe while reading. The human brain is unbeaten by machines in making such connections and determining useful patterns in data, but it is seriously flawed when it comes to store and reliably retrieve large amounts of data without alteration. The brain uses heuristics to achieve efficiency, so its advantage diminishes the bigger the basic set of data becomes.

More formal definitions include that of information as *message,* as *represented pattern,* or *an influence leading to transformation.* This reveals the 'human dimension' of something often considered objective or technical: Information is

closely connected to communication; its character is interactive and interpersonal. You inform *somebody* and you inform somebody *about something* – whereas you simply store, transmit or retrieve data. In the 1940s, Charles Peirce posited that the three basic dimensions of signs consist of an object (semantic dimension), a medium (syntactic dimension), and an interpretation (pragmatic dimension). The third dimension turns attention to the aspect most relevant for knowledge production and learning processes: Information requires a receiver capable of *interpretation*. In the words of David & Foray (2002) "Information is structured and formatted data, passive and inert until used by those with knowledge needed to interpret and process them" (p. 4). Yet 'interpretation' has various meanings. It invariably implies that information has some sort of effect, but this interpretation or transformation need not be conscious or intended.

Finally it is well established that merely receiving information does not necessarily have an impact on people. Motivation or incentives are needed for people to engage in interpretation of information, an aspect that will be further discussed in the following chapters. But the conceptual difference represents a strong source of interdisciplinary misunderstandings that needs consideration in the further course of the project. In general, information can be summarized as data communicated in a context and subject to interpretation which might trigger a transformation. Seen in this light, the ICSU visioning call that research in the next decade should be "solution focused" can be understood as a call to transform the production of scientific *data* into scientific *information* by giving higher priority to context. This leads to the crucial questions of how knowledge is produced, framed and delivered.

The framing, construction and delivery of knowledge influence people's understanding and actions related to climate change, biodiversity loss, risk, or resource depletion. How issues are framed and the ways they are communicated appears to influence people's receptivity to the issues and possible responses (Lukes 1974; Schön, Rein 1994, Entmann 2004). A central theme of recent work on social learning explores what constitutes valid knowledge and how that is dependent on the processes by which it is generated by whom, in what context, and for what purpose (see Ison et al 2007; Wals 2007, Ison 2008). As a result knowledge claims are often contested. This has been very much the case with the climate change debate, especially in the United States (Jacques 2009, Jacques, Dunlap, Riley 2008), and in the ongoing debates about IPCC, 2010.

Scientific knowledge production is one of the most visible processes in this area. The pre-eminence of scientific knowledge is mainly grounded in the fact that the scientific community developed a set of experiments, methods and symbolic language that allows to be read in many cultures, "This is essentially because the receiving parties, despite their widely varying local cultures, share with the originator certain ways of observing, analyzing, describing, and interpreting natural phenomena" (Inter Academy Council 2004, p.30). However, this can be seen as strength as well as weakness when the knowledge produced is requested to provide answers to questions of existential importance to the survival of societies.

Over the last decades, many attempts at theory construction related to knowledge and learning reflected a paradigm shift towards sociological

approaches and process-oriented theories focused on knowledge production, including amongst others the new economic sociology, post-structuralism, neo-functionalism, post-modern theory, the new political economy, and a new sociology of knowledge (Meja & Stehr 2002, Evers 2000). This ongoing trend also resonates in the discussion around transition to sustainable societies, which again involves many calls to create a new science. Sociology of knowledge in particular considers social construction of knowledge and the fact that the history of a society provides crucial determinants of individual thinking. Advanced modes of thought are transmitted to children by means of words, advanced peers help individuals to 'scaffold' and build knowledge. This perspective therefore reveals a direct dualism of behavior and thinking, and in addition also lending much more weight to contextually bound, i.e. informal and local or indigenous sources of knowledge (Vygotsky 1978, Schütz 2002, Kwok 2004)

In some strongly conflicted situations of diverse stakeholders in participatory dialogue, the use of methods such as joint fact-finding and question framing/reframing are designed to stabilize at least a portion of the knowledge (Adler 2002, Stöhr, et al. 2009). The process of joint fact finding, and more broadly, social learning, functions as a form of co-production or at least co-definition of knowledge that becomes the basis for dialogue, shared understanding and, ultimately, concerted action (Ison et al, 2007; Collins and Ison, 2009). By stabilizing the knowledge in this way, the terms of the dialogue can be clarified and a greater chance for agreement on at least a part of the issues is produced.

In a similar vein, studies of science and technology (STS) discuss the co-production of knowledge in the interaction between science and society and in particular policy making (Jasanoff and Wynne 1998; Jasanoff 2004; Lemos and Morehouse 2005). The concept reflects the mutual dependence of science and societal actors to generate identity and legitimacy. Neither science nor politics can claim dominance in this interaction. It is the process of their interaction that generates knowledge and social order at the same time. What is more, both domains draw on each other and cannot proceed without the other one.

This becomes clear in four key areas of co-production as described by Jasanoff (Jasanoff 2004). First, identities of scientists and engineers are formed within the processes of scientific knowledge production. Second, institutions, such as rules of decision making, are created through scientific debates and their interaction with society. Third, discourses are processes in which science and society can mutually create and shape meaning. Fourth, representations of the political and social world are influenced by historical, political, and cultural understandings, which are informed through scientific concepts and theories. A clear delineation cannot be drawn between the political and social spheres and between the norms and values that are shaped by cultural and political, as well as scientific influences.

The knowledge supporting the need to address an issue initially tends to be contested, and a certain stabilization of the knowledge claims is needed before policy is developed to address the issue. Certainly when stakes are high and solutions not easily implemented, the struggle around stabilizing can be long lasting and involve many parties in complex relationships (Funtowicz and Ravetz 1993). The IPCC process and the preceding more natural science-dominated

trajectory are a case in point. Here knowledge stabilization indeed seems to be needed before international policy arenas can start handling an issue.

This does not mean that from that time on knowledge is no longer contested. Conca (2006) has shown that groups may try to delegitimize knowledge that had been stabilized up to the point that international treaties were based on it. This parallels the extensive literature that addresses the importance of the way in which issues and knowledge are framed (Baumgartner and Jones, 1993; Schreurs, Selin, VanDeveer, 2009). The stabilization and possible contestation of knowledge is an important aspect to take into account when we are interested in knowledge in relationship to learning and societal change.

Knowledge as an object of research gained practical importance since the mid-1980s and boomed in the 1990s. The above discussion of the need to interpret data and information already points to knowledge as integral part of the interpretive system of the human mind. Rooted in psychology and neurology are some modern concepts of knowledge, which see it fundamentally a matter of cognitive capability. Knowledge is what „empowers its possessors with the capacity for intellectual or physical action" (David & Foray 2002), or in the words of the World Development Report 1998/99 "everything we do depends on knowledge" (World Bank 1999). The specialized field of knowledge psychology emerged as part of the cognitive sciences, studying representation, acquisition, application and transformation of knowledge. Influenced by constructivistic schools of thought, influential philosophers such as Dewey went so far as to state that knowledge and theories are only tools, and have no value but the ability to use it.

ICSU notes its belief that a "deep base of research and knowledge already exists" in the areas identified as the five grand challenges. However, with regard to the complex processes of climate change, the amount of data and information is very large, but the degree of understanding by stakeholders varies widely and much of the climate change knowledge is contested, as judged by the frequency and intensity of public education campaigns and opposing calls for action and denial on the topic. Therefore considering the use of information is highly relevant. It is also frequently requested that science should deliver information relevant to people affected and decision makers, but this often carries the assumption that the information would be used on its merit – an assumption clearly not supported by observation.

A concept relevant to the KLSC research frame is knowledge systems, as one way of understanding the relationships between different forms of knowledge and their use in contexts. The notion of knowledge systems refers to a set of interrelated cognitions and perceptions that are often related to specific behaviors. The systems are ways of knowing that may lead to quite different understandings or conclusions in certain situations. For example, in issues of land use or resource governance, formal knowledge and local or traditional knowledge may come into conflict when the opposing sides of the conflict each use their own knowledge system without understanding or acknowledging the other's system. As integrative research has shown, these knowledge systems need to fulfill specific conditions to become effective in solving sustainability problems (Cash, et al. 2003). The knowledge and the process by which it is generated should be acceptable to the people affected in the situation, it needs to be

relevant to them in their daily lives, and it has to be trustworthy and credible to them.

The philosophical discussion of knowledge was always linked to the search for truth. As we endeavor to contribute to a discussion about nothing less than the options for the future well-being of the human kind, and as scientists are frequently asked to deliver absolute certainties to policy-makers and societies, it is important to recall that the old question of epistemology remains unanswered to this day: whether objective and universal truth exists and how the perception of the human mind is related to that. Knowledge questions are always heavily loaded with normative or religious connotations. Sometimes practical suggestions based on seemingly objective knowledge are rejected on normative or ideological grounds. Normative factors affecting the trustworthiness of knowledge source however can interact, compete, support, or bias the perceived value of a piece of information.

The discipline most deeply concerned with the scientific investigation of the value and use of knowledge and information so far is economics. With the surge of information technologies and the supposedly cheap or free flow of information and knowledge, the topic attracted much attention. While information technologies influence the way information is used by people, they do not change its fundamental function. Economics and markets in themselves are and have always been entirely an information problem, entailing transactions and coordination between interdependent people. As we consider the use of information for sustainability, society faces the fundamental inherent dilemma of this mechanism – the fact that information is a scarce good itself. No transaction can be completed unless two information problems are solved, first the problem of actors 'not knowing' relevant facts (coordination problem) and second the problem of actors 'not wanting' to act accordingly (motivation problem). Solving both problems takes time and effort, the cost of which is called *transaction cost*. The fact that information asymmetries create room for profits and are thus the basis of entrepreneurship and growth highlight this fundamental fact (Schumpeter 1942).

Behavioral changes will not occur automatically based on new information about sustainability or global change – information on sustainability is competing with other types of information for the attention of people. The transaction cost for acquiring this information as individual or society is rarely considered with the entire set of decisions that in sum generate people's daily life context, even though transaction cost are a well-established theory. Integrating further insights of the humanities in assessing the role of values and norms in the use of knowledge will push the frontier of our current understanding and present a challenging endeavor for the project.

If, for example, a comparison is made between the cases of biodiversity and climate change, there is a notable difference in the extent to which there have been international attempts to understand and frame existing knowledge about these issues. In 1988, the World Meteorological Organization and the United Nations Environment Programme set up the Intergovernmental Panel on Climate Change (IPCC) to study and assess the risks associated with human-induced climate change based on the findings of thousands of peer-reviewed scientific and technical articles. The IPCC is divided into working groups that assess the

physical basis of climate change (Working Group I); climate change impacts, adaptation, and vulnerability (Working Group II); and mitigation (Working Group III). Each working group has released several reports. The most recent assessment (AR 4) released by the IPCC's in spring 2007 states that "warming of the climate system is unequivocal" (WG I) and can be seen in rising global average air and ocean temperatures, the melting of snow and ice, and rising average sea level. In addition, the report concludes that it is very likely that rising average global temperatures are caused by anthropogenic greenhouse gas concentrations. Notably, the IPCC shared the Nobel Peace Prize with Al Gore in 2007. The findings of the IPCC are frequently cited by decision makers as an important reason for pushing forward on an international agreement to follow the Kyoto Protocol. It can be argued that the IPCC's innovative practices for integrating and making sense of climate knowledge has been critical in building an international consensus on the need for action. There are clearly still differences in the extent of concern and commitment among actors and institutions. The recent, much-publicized errors in statements by the IPCC have raised the level of debate about climate change. That debate and consequent or related changes in attitudes, knowledge, and actions may prove to be fertile grounds for KLSC research.

In a related effort that may complement KLSC, environmental pioneer, Paul Ehrlich has launched an initiative, the Millennium Assessment of Human Behavior, MAHB, which intends to catalog human behavioral patterns across spatial and cultural dimensions (see Ehrlich, Kennedy 2005, and http://mahb.stanford.edu/).

In contrast, comparable efforts to assess biodiversity loss across existing scientific efforts have been less comprehensive. While the Millennium Ecosystem Assessment (2005) was tremendously successful in developing an interdisciplinary understanding and strong results among the research community, it was hardly noticed by the larger public. Currently, it is interesting to note that efforts somewhat analogous to the IPCC efforts are forming in relation to biodiversity. The IPBES (Intergovernmental Platform on Biodiversity and Ecosystem Services) has been debated for a while and processes are ongoing to implement an International Mechanism of Scientific Expertise on Biodiversity (IMoSEB) (Koetz et al. 2008). The KLSC initiative may choose to observe and study its emergence in real-time and compare this with the climate change realm.

To what extent does the difference in how knowledge (in this case, primarily knowledge in the form of scientific and technical reports) is structured, influence and shape public and political understanding of the seriousness of a problem? Are there lessons, both positive and negative, to be learned from the IPCC case? To what extent have these lessons already been incorporated into the emerging IPBES? Are similar initiatives in other areas of sustainability desirable? What might be done differently to strengthen further the legitimacy of such major knowledge gathering initiatives? How is knowledge of the changing environment mediated by the various practices and technologies at individual, community and governance levels? By addressing these types of questions, the role of knowledge for societal change, as well as its interaction with learning processes, can be better understood.

Again such questions are closely linked to the ICSU visioning goals of understanding how knowledge can be made usable and how it is used in processes. In addition, these questions show numerous similarities to the well-established discourse on knowledge for development, an area in which knowledge and education have long been supported as the "silver bullet" (Chapman, Mehrotra, World Bank, Meier), even leading the World Bank to declare its own transformation into a 'Knowledge Bank' in 1996.

Considering the amount and breadth of relevant domains of information and knowledge related to sustainability, behavioral and cognitive scientists working in the field of sustainability increasingly focus on complexity and complex information as a fundamental challenge with which human beings must grapple. Natural systems, such as the climate system, include substantial non-linear effects from multiple sources that may lead to emergent phenomena. Even by themselves they are too complex to allow for a complete description and understanding of their operations. What is more, the interaction of the bio-geo-physical systems with social and economic systems adds layers of complexity. Consequently, all aspects of the global entire system cannot be accurately and simultaneously represented by any form of knowledge. Knowledge, which is always changing and evolving, will always contain a degree of uncertainty and be limited by the nature and capacity of human cognitive capacities. There is the constant challenge of dealing with uncertainty and the absence of clear knowledge and understanding that characterizes sustainability questions (Funtowicz and Ravetz 1990; Faucheux and Froger 1995; Chichilnisky 1998).

The limitations on human cognitive capacity and of full knowledge of a system can be addressed by use of models. Models are fundamental to human thinking and functioning. They are descriptions at some degree of approximation of the behavior of things. They reflect perceptions of patterns and efforts to categorize, explain, and predict future behavior. Models are essential in organizing and interpreting information, whether from direct observations done by an individual or produced with sophisticated ICT systems. One area of investigation that KLSC can undertake is to examine the relationship between the construction, use, and understanding of models, both mental (internal) and computational (external or explicit), in shaping the choices of behaviors in response to the complex issues of climate change, biodiversity loss, and resource allocation.

Integrating this emerging field with existing approaches e.g. in economics could provide a highly valuable tool in framing and understanding the incentives and limits for people to actively deal with complex information. In situations experienced as complex and uncertain with multiple interdependencies, a learning agenda becomes a central requirement of moving towards more sustainable practices.

2.3 Individual Learning and Social Learning

Classical philosophers like Plato distinguish knowledge from mere belief, though one of the oldest definitions of knowledge is that of "justified true belief". This definition highlights a distinguishing factor of knowledge in its narrowest cognitive sense – the learning process is an interpretation of information by an

individual taking place before it is transformed into individual knowledge. Information in this process must be qualified as being true, based on the existing knowledge that provides justification for that qualification. This process lays the foundation for the interplay with human behavior, its link to decisions and value systems.

General concepts and approaches to learning processes are numerous and diverse, often bound to academic research disciplines. In one characterization, learning can be understood as all processes of developing, acquiring, and processing knowledge. From another perspective, learning is the process of producing lasting change in the cognitive, perceptual, or affective state of an individual as a consequence of a stimulus or experience. These perspectives are captured in the three classical schools of Behaviorism, Cognitivism and Constructivism. Classic Behaviorism deals with the most obvious aspect of observable changes in behavior, grounded on the works of B.F. Skinner and Ivan Pavlov and thus in a mostly biological perspective (Lefrancois Chase & Joyce 1988). This concept was quickly broadened to include changes in dispositions and behavioral potential as well caused by repeated experiences of a subject in the situation (Hilgard und Bower 1981). Added components of psychology added inner processes of reflection on experience (Kolb 1984, Dietrich 1991), either as expression of cognitive processes based on works by Piaget or as more abstract processes of individuals constructing their reality.

As a common denominator, the term learning of an individual again is a dynamic process. Within the concepts discussed above, this process is the transformation of information into individual knowledge. Learning brings information into concordance or integration with prior states of knowledge and creates the capacity for using new knowledge through understanding. Without establishing a link between prior knowledge and perception (the scaffold on which new building is constructed), new knowledge is highly unlikely to become usefully integrated into a person's cognitive toolbox.

Processes of learning and knowledge-based change are increasingly being discussed in various academic disciplines. Policy learning, social and organizational learning are seen in policy science as crucial for policy change within governments and international organizations. Learning and knowledge acquisition takes place on different levels, in individuals, organizations, communities, and entire societies. For example, Bateson's three levels of learning provide insights into different ways to conceptualize learning in terms of the focus of what is being learned. He suggests first order learning corresponds to routine learning that takes context as given. Second order learning involves learning about the context of first order learning so that is it possible to compare different approaches. Third order learning takes another step outward again, in order to learn about the contexts of second order learning or, as Bateson suggests, to break the habits of level II learning (Bateson 1972). Some have taken this further to suggest that first order learning is about cognition and deals with *knowing*, second order learning is about meta-cognition and deals with *knowing about knowing* and third level learning is about epistemic cognition and deals with *knowing about the nature of knowledge* (Kitchener, 1983 quoted in Bawden, 1995).

Equally established are concepts of social learning. One crucial contribution to the study of social learning phenomena by psychologists has been the approach developed by Bandura (1977). In his understanding, social learning is an individual learning process that is triggered through social contexts such as other people, social situations, and institutions. Learning is conceptualized as model learning where the models from which individuals learn can be presented in different forms via different media: stories, texts, pictures as well actual observable model behavior by others, which is then emulated. The views of Bandura are predated and more fundamentally structured by Lev Vygotsky's (see Vygotsky, 1978). Vygotsky studied and described learning as fundamentally mediated by social interactions, in contrast to Piaget (1952), who characterized it predominately as an individual process. The important point here is that the social interactions lead to learning by processing experiences through interactions with others, e.g. through imitation, discourse, and dialogue (Bohm, Senge).

One special case of social learning is that of organizational learning, since the organization provides a highly defined frame of roles and objectives for a group of people (see e.g. Spender 1996). Research by Agyris and Schön laid the foundation for the modern understanding of organizational learning, taking place in three possible 'loops': (1) lower-level (single-loop) learning: associations between behaviors (explicit) and outcomes, here knowledge transfer between individuals is highly effective, ad leads to short-term problem solving ability which is and highly effective in stable environments, (2) higher level (double-loop) learning: develops interpretive schemes to understand or explain sets of situations, (3) Dynamic routines (third-loop learning): generating patterns of interaction (much like cultural norms and rituals) that result in unique (non-transferrable) organisational features and abilities (McGinn 2001).

Two aspects of this theory merit particular attention: When introduced, the theory was seen as a revolution. Unlike Dewey's, Lewin's or Kolb's learning cycle, where one had, so to speak, to make a mistake and reflect upon it (learn by trial and error) it was now considered possible to learn by simply reflecting critically upon the governing variables implicitly driving our actions (theory in use). In other words, it is no longer necessary to go through the entire learning circle in order to develop the theory further - it is sufficient to readjust the theory through double-loop learning (Finger and Asún 2000).

As KLSC endeavors to understand learning processes able to influence behavioral patterns before they lead to catastrophic consequences for the planet, this explicit aspect provides a valuable starting point. Secondly, the idea of dynamic routines can be seen as a valuable resource for an organization, making it resilient and able to adapt to dynamic and changing environments. As pointed out before, this is a kind of knowledge societies need to deal with long-term environmental change.

In sum, social learning is increasingly a part of modern environmental discussions. However, what is learned and how well it can be subsequently incorporated into changes in attitude and practices strongly depends on the context. The definitions and classifications of knowledge cited above make it clear that it is not simple to transfer or share knowledge and bring about learning in a targeted way. Most important is the understanding that knowledge sharing

does not only involve the transmission of data, but also the communication of a justification in a form that matches the interpretive system of the recipient. This leads back to the aspects of intent and value in the communication of information.

As outlined above, in most information theories intention is absent. Information might be something potentially perceived as representation, though not created or presented for that purpose. Yet in this regard, wide differences occur between scientific disciplines. Natural sciences consider any pattern that forms or transforms other patterns as information, whether or not a central system or conscious mind perceives the influence. The other extreme is economics, which defines information in terms of 'purpose-oriented knowledge' (Wittmann 1959), which requires not only the presence of a human mind, but also introduces intention as an additional defining element of information. Such a narrow approach is difficult to integrate with learning processes and human behavior, since learning takes place both consciously and unconsciously. Information input that kicks off a learning process is often received without clear purpose as any child learning from touching a hot flame realizes at early age. However, it is crucial to acknowledge that an *act of selection* by the learner defines the ultimate relevance of any given information and triggers a learning process.

In this regard, the insights of organizational learning address only one aspect of learning in society. Societies are not organizations; they neither focus on a single purpose nor have a similar strict setup of hierarchies, roles, and functions. Social learning takes place every day in a variety of formal and informal setting, with and without purpose and with or without measurable outcomes. People can simultaneously function with the social learning in an institutional setting and outside that situation in their community or home environment.

This turns the attention to education and pedagogic, the formal or informal intervention in an individual's development to steer learning processes towards a socially acceptable behavior. Originally closely linked to the individual learning processes mentioned above, pedagogical learning theories underwent substantial development over the past several decades. Field studies revealed that test persons were able to easily solve everyday mathematics problems, but unable to repeat the same with a pen on paper (Carraher, Carraher & Schliemann 1985, Lave 1988). This gave rise to instructional psychology and theories accounting for context to improve learning (Collins, Brown & Newman 1989). Technological developments later allowed the setup of controlled learning environments, e.g. in the context of e-learning over the internet. The mixed results of early experiments helped to focus on contextual factors of a learning process, thus integrating aspects of social learning which pedagogic. Today learning theories consider a much richer set of factors, particularly the social mediation of learning in a group. The function of co-learners in 'scaffolding' for knowledge construction or the function of institutions as norm-setters for justifications illustrate this direction.

One current concept highly relevant to the context of KLSC is that of Situated Learning. This approach focuses on systems, in which individuals act as members of social groups and interact with material resources (Gerstenmaier & Mandl 2001), This situation is characterized by learning as an active and constructive process; the aim is participation in a system of shared and distributed

knowledge. Learning is thus described in terms of adaption (attunement) to constraints and affordances. Participating in the community becomes a central element of the learning experience, so the focus of the analysis is the learning environment and the question of effective variables. The concept is a mix of the cognitive and constructivist schools, but with more attention paid to the quality of shared knowledge and knowledge sharing than a classic psychology of context-variables. It thus broadens the traditional approach of learning as cognitive processes towards developing a theory of knowledge construction.

One factor heavily influencing knowledge construction is power. Bacon famously quoted that 'knowledge is power' and since Foucault, it is difficult for social researchers to see knowledge independently from power. (McGrath 2001). Nevertheless, in international political discourses on development and sustainability knowledge often retains a glow of something wonderful and beneficent, with power mostly discussed in terms of north-south knowledge asymmetries (Denning 2001). Considering the need to validate knowledge as part of a learning process a broader set of questions is needed: What processes generate broadly 'valid' or accepted knowledge in a particular societal context and what modes of communication of knowledge about climate change and biodiversity loss are required by individuals, groups, and societies to enable changes in understanding and practices?

An interesting case is the shift from language such as "protection" to ecosystem services or a more widely applied trend towards valuing of services, be it by ecosystems, resources in general or issues such as social cohesion. The question can be asked and should be assessed, whether or not these different ways of framing offer new insights for changing behavior and if so, is it due to avoiding politically sensitive terminology that may enable break-through in international negotiation processes, or is such a new thematic focus indeed able to help understanding a given topic differently.

It is also important to take into account that knowledge from different types of sources may be differently used and accepted. In different cultural contexts, different kinds of knowledge may have greater acceptance. Who delivers a message can also be important for its legitimating. To what extent do we understand how the structuring, presentation, and source(s) of knowledge influences the extent to which it is viewed as legitimate? And in the perspective of KLSC, how does legitimacy, however established or contested, affect behavioral choices? One recent concept highlighting the effect is that of 'high-powered' knowledge by trusted people and institutions (which may be wrong) and 'low-powered' or 'zero-powered' knowledge by sources not known or trusted e.g. in patronage situations (which may still be correct) (Clift 2001). This also includes the role of gatekeepers, role-models and multipliers who may have a disproportionate influence on group behavior.

We recognize that the ability to shape the ways in which discussions about subjects as complex as climatic change, resource use, and biodiversity evolve is closely intertwined with power. Knowledge must be legitimated to have influence. The credibility, respect, and persuasiveness of the framing of information can be central to its effective communication. Institutional structures can strongly influence which groups in a society have voice and influence. Thus, the way that institutional structures promote or inhibit the generation and dissemination of

sustainability knowledge is clearly significant. Equally important to KLSC is the cultural and economic context in which societal change occurs or is even considered. The issues deemed critical in one context may be seen entirely differently in another context or culture. Understanding the constraints and perspectives on knowledge, learning, and societal change is then crucial to developing effective strategies and meaningful implementation on a larger and more inclusive scale.

One typical example of relevant power factors concerns educational systems. The international polity often assumes that higher education institutions have an inherent innovative power to match the pace of changes in society and implement new ideas (Plomp 1999). But in fact publicly financed education institutions usually rather follow innovations from the economy (Reinmann 2005), educational reformers regularly face conflicts with established practitioners (Jonsson 2004). So while most major developments in education have political and ideological foundations, the practical construction and implementation follows mostly institutional interests (Evans 1995). This also relates to scientific knowledge, with the scope of permissible moves in research determined by power structures, and scientists not necessarily promoting interests humankind (Denning 2001)

In sum, the previous has highlighted the need to pay attention to the coding of our information about sustainability, the critical role of perceptions, motivation, values and justification, as well as potentially helpful approaches to better support learning for sustainability. However, the behavioral outcome of any formal or informal educational intervention is not created as an automatic outcome of such processes. Learning builds on prior knowledge and learners will attempt to make sense of anything unfamiliar. When they do so, the meanings they construct may be quite different from what was intended if they cannot activate an appropriate context for learning. Just as is acknowledged for early development: "Children are ignorant but not stupid: Young children lack knowledge, but they do have abilities to reason with the knowledge they understand" (National Research Council, 2000, p. 234). Again the fact that information about sustainability is highly complex presents KLSC with a big challenge: People will try to build highly complex facts into their current living context, and not necessarily seek to build the knowledge scaffold needed for a meaningful interpretation. This way of dealing with complex information, also called “naïve interpretation” (Schulmeister 2006) makes the outcome of learning for sustainability highly unpredictable. Both obstacles to learning as such, and obstacles to subsequent behavioral changes have to be considered.

Learning may be inhibited by fear or disdain or supported out of excitement. The kinds of shifts in behavior being asked for to move societies towards low-carbon futures can be frightening. It may be for this reason that it often takes a crisis for major changes to happen (Slovic, Finucane, Peters & MacGregor 2006). Habits also are a barrier to change. For individuals and organizations, it is usually easier to continue to do what one has always done. Routines are formed for a reason. They help to structure our world and limit the need to make constant choices about everything. As a result, routines are often hard to break (Kahnemann, Knetsch & Thaler 1991). Empirical studies on double-loop learning in organizations showed that the initial reaction to errors for many people is to look for another strategy that will address and work within the existing governing

variables, i.e. to stick with single-loop learning and not question our underlying motives as long as possible (Argyris and Schön 1974)

As for behavior, psychology traditionally has taken the view that cognitive knowledge is a precondition for conscious and deliberate decisions by individuals. It can be distinguished from habits that are relevant for understanding everyday routine human behavior, but that include little conscious deliberation. In countless psychological studies, it has been shown that cognitive knowledge plays a minor part in explaining human behavior, while other factors such as habits, social norms, attitudes, given infrastructures and context conditions in which knowledge arises or is situated are in many cases more relevant to understanding behavior (Deci and Ryan 1985; Ajzen and Madden 1986; Gigerenzer 2000).

Changes in behavior for sustainability typically require going against existing habits. When that behavior is habituated, such as getting in the car and driving to work alone instead of car pooling, taking public transportation, or riding on a bicycle, it can be difficult to alter even when learning has taken place. Giving up the necktie in the heat of the summer (as is being pushed for by climate policies in Japan) is a behavioral change difficult for many as it is a strongly habituated and socially enforced dress code. Exploring ways of introducing ways to provoke re-calibration of habits of practice and mind, such as through cognitive dissonances (see, for example, Festinger 1957, Harmon-Jones and Mills 1999) is important in changing patterns.

In policy settings as well, there can be a 'stickiness' to existing ways of doing things. Policies continue along a certain path because that path is well worn. Moreover, interests tend to develop around the status quo and they usually have an interest in maintaining things the way they are. Learning can even be used to better justify inaction. Empirical research showed that people naturally resist higher or second-loop learning, operate from their initial theory-in-use for as long as possible, and as primary action strategy seek unilateral control of the environment and task plus the unilateral protection of self and others. This often leads to deeply entrenched defensive routines on the individual, group or social level (Argyris 1985, Edmondson and Moingeon 1999, Agyris 1990). Such behavioral patterns suggest that current research approaches strongly underestimate the importance of local and indigenous knowledge, as they mostly focus on its contents but not on its importance for value systems, local theories-in-use, and hence its role in learning processes.

Better understanding of how sustainability learning has occurred or been blocked may shed light on ways that such learning processes could be stimulated. It is often said, for instance, that one reason that recycling spread as quickly as it did had as much to do with the power of the voice of children as it did with economic considerations. Children who learned about the importance of recycling in schools took this message home to parents, who in turn, were pressured to begin separating and recycling waste. It may well be that children, receptive to new ideas and new practices, can in many important areas be some of the most persuasive carriers of sustainability messages.

An interesting behavioral facet of the concept of knowledge systems is the reflection of globalization in Knowledge Sociology: A vivid discourse has arisen on

a rather new particular way of constructing reality, namely the necessity of individuals to now consider all aspects of life, social organisation, economic activities, spatial arrangements and others under a world-wide perspective (Evers 2000). This is so complex that it often exceeds the cognitive capacities of individuals, leading to reactions ranging from denial to aggressive opposition.

Social movements and communities of learning or practice (COP) (see Lave and Wenger, 1991; Wenger 1998, 2002) constitute another domain which can be examined for insights into how learning and knowledge, focused around a set of values begins within a small group or an individual leader to become a more widespread and acknowledged community of advocacy and action. Key to the community of practice is the development of a shared sense of purpose and learning through ongoing interaction within the community. Thus three key characteristics are essential for a community of practice to be said to exist: the domain or shared interest among the community; the community itself comprising those members that interact with each other; and the shared (and evolving) repertoires of practice which arise from the interactions.

Social media and networks, such as communities of practice (see Wenger 1998) are increasingly important mechanisms for distributing knowledge, increasing engagement (if not understanding), influencing attitudes, and changing behaviors regarding global change issues. The rapid spread and adoption of social media and the tools for participating and communicating widely by widely dispersed individuals, groups, and institutions has changed the entire process of communication and, more importantly for KLSC, the process of acquiring and assimilating knowledge and promoting actions.

Networks – both informational and organizational, can be important transmitters of ideas. Organizations such as ICLEI --Local Government for Sustainability, the Clinton Climate Initiative, and the C40 Large Cities Initiative are examples of network organizations that are working to disseminate information about sustainability practices and needs among cities. Given the growing percentage of the global population that is living in urban areas, stimulating change at the urban level can be a powerful way of reducing the ecological impact of cities. This would integrate well with the IHDP project on Urbanization and Global Environmental Change (UGEC).

Many other kinds of networks exist as well. Schools and universities are creating networks that promote the exchange of information about sustainability practices and an element of positive competition (e.g. the recycling Olympics) among young people as they work to green their schools and campuses, promote more efficient resource use, and demand more sustainability education. One such network, the Alliance for Global Sustainability (http://theags.org/), links the Massachusetts Institute of Technology, ETH Zürich, Chalmers University of Technology, and the University of Tokyo and serves both faculty in research project coordination and students in engaging in collaborative projects and competitions.

It is important to understand in which areas and in which places networks are and are not arising. It is also important to learn more about how networks operate, which of their practices are successful and which not, and what might be done to improve their effectiveness. It is also critical to consider what could

be done to expand the channels for sustainability learning across those who are already actively working to promote it.

There is little systematic or indeed systemic knowledge about what the communication mechanisms are that are being used to spread information about sustainability, what kind of messages are being spread, and how effective such efforts are. In what ways is the Internet being used by a range of communities and individuals to promote sustainability and is the internet an effective channel for fostering changing views and behavior? How much attention does the media give to sustainability questions with the system level focus as opposed to single-issue agendas? Are non-governmental organizations – both, large and small – effective communicators of new understandings and practice, which are contextually relevant and feasible?

It is not only a question of what medium is used for communication in what communities, but also who is communicating and what is his or her role in the community that makes the communication effective. In other words, what is the role played by leadership in promoting social learning, knowledge and change? What do leaders do that fosters social change? We can also ask if and how leaders opposing change use knowledge and learning in some fundamentally different manner or use different information and interpretations to recruit people to their cause? What are the links to change agents and social entrepreneurial organizations? This is also an area in which a substantial amount of scholarship and action research has been done. Here the role of practitioners as partners in KLSC is vital.

In the existing literature, the purpose of such communities is to serve learning, respond rapidly to requests from peers, develop, capture and transfer best practices, promote dialogue, link diverse groups and promote innovative approaches. However, given the use of advanced technologies, many COPs tend to represent not the stakeholders of a particular issue, but those who are in a position to participate (Cummings, Heeks & Huysman 2003). Furthermore, research on online forums showed a high level of agreement among members, which suggests a tendency to form coherent groups and separate opinions instead of seeking active dialogue. While a certain coherence in a group provides scaffolding for individual learning, a lack of constructive criticism, challenge and opposition from peers will effectively block learning (Stark & Mandl 2003). It seems that knowledge-building communities require sophisticated social engineering elements and levers to enable learning for sustainability as much or even more than real-world communities (Scardamalia, Bereiter & Lamon 1995, Collins & Bielaczyc 1997).

2.4 Societal Change and Transformation

To redirect the development of human society in a more sustainable direction, societal change is needed. By societal change, we mean large-scale behavioral change spanning the levels of societies that helps to improve societal and ecological conditions towards sustainable development goals. Societal change is the sum of the behavioral and collective changes by individuals, groups and formal institutions. In many instances societal change related to global issues

has been viewed as the process of formal implementation of international agreements. Much less attention has been devoted in the literature on international environmental policy on the translation of the formal process in a lived process on the micro level (e. g., The Social Learning Group 2001, Mitchell/Clark et al. 2006, Moser/Dilling 2007).

People are subject to material, natural and social restrictions, the latter including cultural goals, values, the knowledge base, symbols, frames of reference, special codes of social subsystems, and institutional means. Hence our actions are determined by external conditions, expectations, and judgments in any given situation. A range of disciplines provides insights into the behavior and action of individuals and social systems, most prominently, behavioral sciences and behavioral economics, theories of collective action, and sociology. These provide us with core approaches to understand the positioning of individuals in collectives e.g. through habits and processes of socialization.

A classical view of the link between knowledge and action directed at invoking societal change has been that knowledge would, or at least should, lead to appropriate rational action. Scientific insights are expected to lead to technical and political responses that will address health, environmental, and other policy problems. However, neither the direct link between knowledge and human behavior, nor the direct connection between scientific insights and societal decisions are unchallenged in recent findings in different disciplinary perspectives. The most common example is the traditional and still widely used (and taught) assumption of economists that decisions are based on transient preferences, a postulate that is fully falsified by cognitive research. The fact that individuals often act differently depending on the collective they are currently situated in (e.g. as employee or as family member) illustrates the difficulty of understanding the knowledge-base used to decide on a course of action or the knowledge needed to induce change.

Focusing on changes towards sustainability raises an additional challenge. The term sustainability is used in so many different domains and contexts that it is almost impossible to provide a concise review of its origins, usage and associated meanings. What is clear is that knowledge, learning and societal change are inextricably bound to notions of sustainability, in that sustainability gives a sense of purpose and provides some answer to the questions: knowledge for what? Learning for what purpose? In terms of social change, sustainability supposedly is a key measure of success: desirable actions should lead to an improvement in the situation.

There are however, no easy answers to what constitutes improvement. This is at the heart of the concern in this proposal with the interplay between knowledge, learning and social change. The precise arrangements of society and environment are largely unknowable in advance because of the inherent complexity and interdependencies, which mean that no individual or group is likely to have sufficient competencies or powers to develop unilateral actions sufficient to constitute improvements for the wider society. In this kind of situation, humans are reliant on their ability to learn to adapt and adapt to learn. Thus, knowledge, learning and social change is understood as both a response to and form of adaptation to environmental change. Ultimately the decision what constitutes improvement is a normative political decision to be made in the

frame of the societies political systems. To understand the transformation of society it is therefore crucial to analyze the economic, ecologic, social, and institutional societal subsystems, e.g. industrial transformation, governance systems, or consumption patterns.

Societal changes can be analyzed from various angles, the most prominent perspectives being the dynamic or speed of change, the direction of change, the level of change, the duration or persistence of change, and the source of change.

Societal change can be fast. We observe changes that lead to radically new developments and behavioral patterns in societies. Classical examples are revolutions that overhaul political systems and require entirely different patterns of political decision-making, administration, discursive practices and educational systems. Other examples include the rapid changes in purchasing behavior in the case of new information on harmful effects of consumer products. Likewise, new products can sometimes expeditiously change behaviors on large scales, such as mobile phones. In the climate discourse, a shift in the level and intensity and hence the sense of urgency of the debate followed the publication of the Stern Review (Stern 2007) and the IPCC's (2007) Fourth Assessment Report.

Revolutionary change is well studied in history, sociology, history of science and related disciplines (Kuhn 1976/1991; Skocpol 1979; Johnson 1983). Although this literature rarely focuses on environmental implications of revolutionary changes, much can be drawn for the analysis of behavioral changes with regard to earth system transformation (Radkau 2000). Most studies analyze negative rapid changes in societies resulting from changing environmental conditions. In situations of collapsing societies or social systems, social factors often play crucial roles (Axtell and Epstein et al. 2002; Diamond 2005). Yet these studies only partially explain why and how rapid change towards solving global environmental problems occurs.

A recent approach applies the notion of tipping points (Grodzins, 1958) as known from catastrophe and systems studies to social systems (Lenton et al. 2008). The notion of tipping points draws attention to the possibility of irreversible system level shifts to a new system state. Social tipping points are seen here as processes where small-scale events induce large-scale changes in social systems (Gladwell 2000). While the concept and empirical application of tipping points has found resonance in the natural sciences, its application to social systems still provides challenges (Moser and Dilling 2007), not least in terms of determining the interplay of factors and drivers, and knowing when the threshold is reached and a new 'state' is in place. Recent work (Scheffer and Carpenter 2009) suggests that researchers need to be increasingly aware of and develop ways of making sense of the indicative 'squealing' of these systems prior to the tipping points being reached. The KLSC project would promote research into understanding how to identify a tipping point in attitude and behaviors and how changes in knowledge and understanding by a group or community leads to a tipping point in attitude and practice among the members of the group. One classic concept featuring strong similarities is that of a 'critical mass' in collective behavior (Schelling 1978). These works are of particular importance as they highlight how outcomes of social selection processes might be against both the interest and explicit wishes of all individuals involved. New works considering what is called arbitrary coherence, and the influence of anchors and relativity

might further inform such approaches (Ariely 2008). It is finally worth noting that concepts of critical mass, tipping points, system stability, and resilience originate in natural sciences. Drawing on such studies to develop new innovative ideas to understand social dynamics and scenarios for potential far-reaching regime shifts might be highly valuable.

Many processes of societal change are gradual and follow evolutionary dynamics that last years, decades or even centuries. Here, innovations and novel insights diffuse stepwise, often meeting severe resistance, being neglected, or even forgotten. Unlike evolution in natural systems where change occurs over many generations, social and social-ecological systems often evolve through communication, negotiation and conflict resolution within the lifespan of one or a few generations. These dynamics apply for example to the phase-out of chlorofluorocarbons (Litfin 1994; Benedick 1998; Andersen and Sarma 2002; Canan and Reichman 2002; Parson 2003; Jänicke and Jacob 2004), to the implementation of environmental management schemes in companies (Pesonen 2000; Freimann and Walther 2002; Morrow and Rondinelli 2002), or to the development of air pollution abatement systems (Mathews 1997; McCormick 1997; Turco 1997; Jagusiewicz 1999; Siebenhüner 2002; Tuinstra et al. 2006). One difficulty is to understand the link between micro-behavior and macro-shifts in such a process, the sources and motivations for change. Similarly challenging is the question of when such evolutionary processes take place within a current value system and when baseline shifts occur.

In the IHDP project on Integrated Risk Governance, sustainability is defined in the negative by saying that un-sustainability is taking risks that exceed society's coping capacity. The issues that KLSC can consider in this perspective are the factors that influence behaviors in relation to the knowledge, understanding, and mental models of such excessive risks among members of different cultural and socio-economic groups.

Social learning concepts have contributed to the understanding of these gradual, as well as more rapid processes, particularly in the field of global environmental change.[3] These studies highlight the conditions of learning and change that predominantly adapt to external pressures or that include basic values and related behavior into the change process. They also gave rise to questions regarding the connection between knowledge and behavioral change on societal levels or to the interaction between knowledge and other societal driving forces such as political power structures, economic pressures or technological developments. In addition, there is not yet much understanding of the failures and interruptions of social learning processes and of the role of issue-specific factors, e.g., those that distinguish climate mitigation from adaptation or the protection of biodiversity.

Evolutionary economics has addressed processes of societal change and learning for a long time. Here societal change is explained on the basis of evolutionary

[3] See for example the following: Parson and Clark 1995; The Social Learning Group 2001; EEA 2002; Siebenhüner 2005; Pahl-Wostl et al. 2007; Wals 2007, Van de Kerkhof and Wieczorek 2005; van Kerkhoff and Lebel 2006. Ison et al 2007; Blackmore 2007; Collins and Ison 2009.

dynamics where individuals, social entities or entire societies are required to change when selection forces in a competitive environment force them to develop new responses and to find better solutions to the problems of survival. These concepts study routines and technological paths as well as the processes of routine development and path creation and path breaking (Nelson and Winter 1982; Hodgson 1993; Coriat and Dosi 1995; Dosi et al. 1996; Witt 2001a.). While evolutionary economics has been focused on technical developments and the supply side, only recently have consumption behavior and its changes over time become an object of study (Witt 2001, 2001c). The latter field is of particular interest to the analysis of knowledge-driven societal change in the area of earth system transformation.

From the perspective of direction of change, significant research has been devoted to bottom-up processes of societal change and how it emerges out of individual and group initiatives. In the social and planning sciences, there is a rich body of understanding on why, when and how societal change takes place. In social psychology, numerous studies have shown the effectiveness of different ways and instruments to induce individual, group and larger scale behavioral change. There is an extensive set of literature on advertising and marketing (Vakratsas and Ambler 1999, Sutherland and Sylvester 2008) as means for influencing behaviors. However, behavioral change in those cases is often not through accepted and validated knowledge or learning, but rather by implicit emotional drivers. The role of knowledge and understanding in these processes is not yet well studied and much of this knowledge is widely dispersed in many academic disciplines and not readily accessible to other communities.

Structured intervention to manipulate the behavior of members of a social collective is well established in systems of formal education. Research on economics of education as such started in the 1950s with Vaizey and Schultz studying the cost of education and investment in human capital respectively, but it was developed more fully only in the 1970s, when demographic pressures sharply increased the cost of education (Rumble 2004, p. 9). Scarce public funds caused strong political interest in cost efficiency and quantity in access numbers, so from the beginning the research field had a strong focus on cost effectiveness, begging the question of what effectiveness meant with regard to learning outcomes, particularly over longer time periods. This affects the current situation in education that emphasizes discrete disciplines and operational skills, rather than problem-based, trans-disciplinary learning, collaboration, and communication. For KLSC this raises the question of if and how the knowledge and learning in both formal and informal educational settings influences the sense of agency and responsibility of students and families in terms of sustainable practices.

Another important literature reference on social change processes linked to learning and personal development is Otto Sharmer's U Process. Bohm, Senge and Scharmer and to some extent other authors within the domain of leadership for change bring an interesting approach to how problems/reality are framed by individuals and how this affects social processes, which can be seen as one of the central questions when looking at bridging the knowledge/learning/action gap by creating an environment that promotes social learning (Bohm 1996, Senge 2006, Senge et al. 2004, Scharmer 2007).

Regarding the persistence of change, there are times when new practices diffuse, but then over time begin to fade from use. For example, after the first oil crisis in the 1970s, in many countries there were campaigns to convince individuals to save energy, and to some extent, these campaigns worked. Yet, over time, as the energy crisis became more distant in people's minds, their conservationist habits faded. This suggests that in many cases continuous learning is critical for the implementation of sustainability behaviors. It should not be assumed that lessons learned by one generation will necessarily be understood and adopted in subsequent years, much less by subsequent generations, without adequate education.

Knowledge, learning, and behavioral change for sustainability are necessary at all levels and across different societal sectors. Major shifts from the status quo will be required to achieve a more sustainable world. This will require the scaling up and diffusion of many pilot initiatives (Gibson, Ostrom, Ahn 1998). There are countless examples of specific best practices for sustainability—the individual who builds a passive house, the school that decides to only buy green power, the restaurant that minimizes food waste, the farmer who limits the use of pesticides. These practices, while laudable, are often too small on a regional, national, or global level to have much impact unless many others follow similar practices. Scale matters, meaning that expanding communities of practice and strengthening networks of such communities is essential. They help link individuals with a shared sense of vision and purpose, so that individual changes are undertaken in the context of a wider social movement. The challenge becomes finding how to develop a sense of shared purpose between the different scales of activity which allows knowledge and learning to flow between the different scales and thus effect changes in practices at all levels which can lead to concerted action for sustainability (see Collins and Ison 2009).

There are many examples of local initiatives that provide a look at the question of scaling up. China has chosen a handful of cities to become model environmental cities – cities whose ecological footprints are well below the average. In Germany, there are half a dozen towns that have chosen to go 100% renewable. In Japan, the government requires that governmental off ices not be cooled below 28 degrees C in the summer time. In the Netherlands, a third of the population commutes to school and work by bicycle. Bogota, Columbia has introduced one of the world's most eco-friendly public transportation systems. Costa Rica has allocated a third of the country as national park in an effort to protect biodiversity, while stimulating ecotourism.

Change can be considered as occurring in different or multiple scales or levels. These include the following:

Local arena: One crucial arena for change in the direction of sustainable development consists of communities, neighborhoods and initiatives on the local level. Promoting sustainable lifestyles, implementing Local Agenda 21 initiatives, launching community projects, bringing together local actors and reaching out to other communities and regions are challenges and learning tasks for local communities in this respect. Social learning is a desired outcome of public participation processes and at the same time, public engagement may stem from greater awareness and social learning around a particular issue (Webler,

Kastenholz et al. 1995, Johnson and Wilson 2000, Dietz & Stern 2008, Collins, Colvin and Ison 2009).

Domestic politics: This class of approaches addresses questions like: How do political systems and particularly political decision makers learn? Where does the knowledge come from that is applied and diffused in the learning process? What has been learned? How could the resulting changes be measured? The different concepts in this field vary in their focus on the learning agents. Some focus exclusively on governments such as Etheredge (1981), while others like Heclo (1974) and Sabatier (1987, 1988) additionally examine societal actors such as elite structures, networks, and other social groups as learning agents. The latter approaches stress the role of norms and belief systems in learning processes within a network structure, called "advocacy coalition" by Sabatier.

International relations and comparative country case studies: Another group of studies in policy learning address the international arena and investigates whether and how states learn from each other and whether and how international communities are able to learn (Schreurs 2002). Rose (1991, 1994) addresses issues of "lesson-drawing" where one state benefits from the experiences made by other states. The concept of epistemic communities as developed by Peter Haas (1992) and Adler (1992) draws the attention to mostly internationally organized networks that are united by their shared beliefs and convictions about particular political problems and the favorable solutions to them. These networks usually consist of scientists, lobbyists, political decision makers and advocacy groups. Insights on issues of sustainability in the field of learning between countries are to be found in diffusion studies, which analyze the spread of (environmental) policy innovations across countries (Jänicke and Jörgens 2000; Tews and Busch et al. 2003; Lafferty 1996, 2004).

The global society as a whole: Many environmental problems such as climate change, ozone depletion, biodiversity loss, health problems such as life-threatening diseases like Malaria, Tuberculosis, HIV/AIDS and others are global threats to the entire human society. Humanity has countered a number of these problems successfully through forms of collective learning. A number of authors developed conceptual frameworks for the understanding of this kind of global learning. These draw on empirical case studies of particular learning areas such as combating plague, cholera and smallpox (Cooper 1989), implementing Keynesian economic policy (Hall 1989) or managing global environmental change (The Social Learning Group 2001).

Sustainability learning often occurs from acquiring knowledge about best (and worst) practices in other countries, towns, or villages (Tews, Busch, Jörgens 2003). The idea of 100% renewable electricity cities, while still limited in scale, is beginning to grow in Europe. Through observing first movers and early adopters, other communities learn that achieving 100% renewable electricity is feasible and then begin to find ways of implementing strategies at home. There is growing attention to sustainability best practices and how these practices might be implemented in other groups and societies. The choices of some cities to close off their inner shopping districts to automobiles to promote more attractive atmospheres is a practice that has spread widely, presumably due to a process of cross-city learning.

Of course, not all learning that is initially thought to be sustainable turns out to be best or even good practice when viewed from a more systemic perspective. The initial rush into biofuels as a 'sustainable' alternative to oil during the price hikes of 2007 and 2008 were quickly countered by voices raising concerns about food security and biodiversity loss from agricultural and forested land that was suddenly being diverted to biofuel crops. This suggests a process where learning was occurring, but which had insufficient safeguards in place for precaution and making sense of unintended consequences of the new practices. In other words, the learning was undertaken with limited insight about the system-wide effects.

This example cautions us against assuming that learning always leads to a more sustainable outcome. The extent to which learning contributes to a more sustainable society is dependent on the ability of those involved to appreciate the complexity and interdependency of the elements of the situation they are in. This illustrates the crucial role of sense-making and reflecting as we learn, and highlights the need for second- and third-loop learning with revision of theories-in-use and an awareness of how our epistemologies might constrain moves towards more sustainable behavior (Collins and Ison 2009). It also connects to the need for building, testing, and communicating with meaningful models and scenarios that help consider the range of conceivable outcomes of actions or policies.

Many of these examples are in-and-of-itself what could be called a best practice. Yet, unless such kinds of examples are scaled up, there net impact on global sustainability will be limited at best. The world is full of entrepreneurs. At the individual, organizational, regional, and national levels there are already many good sustainability practices that have been put in place. The question then is how such good examples can be more widely implemented, so that their impact can be enhanced. Scaling up may happen as a result of what David Vogel has called regulatory competition (Vogel 1995). In the environmental policy field, it is not uncommon for the standards that are established by ecological pioneers (Jaenicke, Jacob 2004) to be adopted by other businesses and countries that wish to remain economically competitive or to hold on to an image of being modern and environmental, This is one reason Vogel argues that there is not an inevitable race to the bottom in environmental policies. Yet, clearly, not in every case do best practices diffuse. Nor do they diffuse to all regions equally quickly. Scaling up action for sustainability needs to occur along both vertical and horizontal dimensions. The active diffusion of sustainability practices across regions is another way to achieve scaling up. When good ideas introduced in one location can be introduced through appropriate forms of knowledge and learning and catch on in others, the scale of action grows.

A core aspect related to designing and assessing scaled up approaches of local practices is overcoming the huge conceptual gap between analytical tools for micro- and macro-level theories. This discrepancy between explanations for individual behavior and collective outcomes is present in almost every discipline.

Methodically, arguments on both the macro-oriented policy level and variables on the micro-oriented implementation level are based on empirical analysis. But linkages to the respective other level are neglected, leading to typical flaws in the analysis: Macro-oriented analysis relies on highly aggregated data and thus (over)simplification; failure to disaggregate such variables veils variations in

policy-responses from different socio-economic actors (i.e. annual data in case of shocks). One specific project will never target the entire population of a country or region, and average characteristics derived from macro-analysis will neither conclusively show whether it should be promoted at all nor help to assess the needs of the specific target audience. Micro-oriented analysis respectively includes highly specific data, often lacking comparability. Failure to embed such data into a context can veil inconsistencies and performance variation (Stallings 2000, Michaelowa 2001).

Although empirical quantification in educational analysis is seen as especially problematic (Jung 2001), the problem is a general one: Modern empirical data gathering in policy related social sciences dates back to the Yale Political Data Program in the 1960s, and until today includes and builds on concepts that basically are both too abstract to translate into a particular program and too "unreal" to manipulate for policy-makers (see Maier 1999). The translation of 'expected utility' in conflicts or of 'relative deprivation' into a particular policy program is in the least "hard to envision" (Eberwein 2004). Empirical research is not innately sufficient to bridge this gap. Even using the same empirical data, development professionals and policy-makers may therefore draw conclusions quite different from educational and e-learning professionals.

Policy papers, evaluations and case studies concerning local behavior and initiatives on environmental action frequently neglected either disaggregation in macro-analysis or context-setting in micro-analysis. Therefore the link between local knowledge systems and the international knowledge stock is almost impossible to conceptualize with our theoretical toolbox.

Societal change can also take place under conditions that require immediate reaction, such as a catastrophic event, without the deliberate effort to generate new knowledge and learn collectively. This may lead to longer term changes not only in behaviors, but also in understanding and attitudes. In such cases, basic values or dominant cognitions in society may shift without society-wide discourses or deliberate choices taken by the majority in a society.

There is a range of behavioral patterns that often contradict generally shared norms and understandings. In environmental research, this process dynamic has been found in several instances. Many consumption decisions openly contradict verbally expressed good intentions of individuals. For example, mobility choices in industrialised countries may also be driven by overriding factors such as expense or lack of easy access to public transportation, in contradiction to expressed values or knowledge (Heine and Mautz et al. 2001). In other terms, individual decision are made under conditions in which norms and ethics are in conflict with other factors, which may be dominant.

The concept of shifting baselines covers some aspects of this phenomenon. Originating in social psychology and ecology, it describes the subconscious change of perceptions and terms of reference over time, in particular from one generation to another (Pauly 1995; Dayton and Tegner et al. 1998). Here, most individuals refer to the conditions they became used to in their youth and fail to perceive longer time perspectives. This has extensively been studied in the case of fisheries and oceans (Roberts 2003; Sáenz-Arroyo et al. 2005) and could be extended to other fields of environmental degradation and ecosystem overuse

(Welzer 2008). The research challenge is to understand the cognitive dynamics of changing perceptions vis-à-vis highly dynamic environments and how perceptions can be promoted that are more adequate to the problem dimensions and its dynamics.

There can also be complete denial or ignorance in societal reactions to global environmental change. Often societies are well informed about problems, but show no sign of learning or behavioral change. They may not have the social or cultural structures to value scientific data and try to continue conventional development paths. In this case, there are no significant changes in either public perception and discourse or in the dominant patterns of behavior. This limited capacity or refusal to learn and change can also be open and deliberate (Cohen 2001) or simply a lack of appropriate incentives. In environmental policy, this phenomenon occurs often with regard to global problems such as climate change and loss of biodiversity. On climate change, focus groups showed several mechanisms of denial and barriers to linking the global phenomenon to their daily lives and lifestyles (Stoll-Kleemann et al. 2001). Other examples include the neglect of scientific warnings of ozone depletion in the early and mid 1980s (Milburn and Conrad 1996). Likewise, in the preparation of IPCC reports, several governments openly expressed denial of climate science (Siebenhüner 2003).

Conceptually, processes of denial or ignorance can be understood psychologically as reducing cognitive dissonance or the denial of fundamentally challenging insights. Theories of cognitive dissonance (Festinger 1957, 1978; Elliot and Devine 1996) explain selective perception and denial on the individual level. What remains to be further explored are the social and individual dynamics, motivation, and cognition that affect the ease or difficulty with which people change their perspectives and choices of behaviors. More recently, there is a growing sense in which refusal to act is being seen as a rational choice in the face of increasing uncertainty about the scientific 'facts'. This exemplifies a bounded rationality in environmental issues (Simon, 1990; Gigerenzer, 2004). Personal experiences coupled with high profile disputes over climate change projections and anticipated effects, such as glacial melt and corresponding retraction by the IPCC (IPCC 2010), add to this growing unease. The tension between specific scientific knowledge and thinking and the campaigns to discredit or deny the science will also be a fruitful area for research. Central to this will be the role of trust in relation to knowledge, learning and social change and the key factors that determine how trust leads to new understandings and practices (Siegrist, Earle & Gutscher, 2010). This will extend into research to understand the reasons for success or failure of certain discourses among the public, scientists, and corporate or governmental voices.

3 Research Framework

3.1 Characteristics of KLSC Research

The essential and interrelated characteristics of the research that are envisioned within the KLSC framework are interrelated and are outlined in this section.

3.1.1 Integrative and trans-disciplinary

A highly integrative and trans-disciplinary approach is required for KLSC because it is focused on the interplay between knowledge, learning, and behavioral and societal change, rather than on any one of its three components, and because each of these intellectual domains themselves have been developed through contributions from several disciplines. The research and activities of KLSC will build upon the extensive body of existing literature in the three components, draw upon current projects in related fields, and explore new directions and methodology.

For example, learning in the context of the KLSC initiative includes the perspectives of many disciplines, including social psychology, sociology, management studies, natural sciences, systems studies, media and communications, and education. The focus on climate change, biodiversity and resource allocations in transition to a sustainable future helps to focus this research by examining knowledge and learning not in themselves, but in relationship to policy- and action-relevant knowledge and necessary change toward a more sustainable future. The three components in the focus are aspects of ecosystem services, but the purpose here is to narrow the contexts for research, yet maintain the connections to central issues of significance for global change.

3.1.2 Sustainability as a research issue and normative goal

Research and activities within KLSC are explicitly intended to support a normative goal of furthering sustainable societal actions, but to do so through the highest standards of rigorous scholarship and research. That is, the research conducted by KLSC must continually probe the assumptions and question the processes that are undertaken or proposed to lead from existing knowledge to new practices that may be more sustainable. That means not only questioning and conducting research on knowledge production, learning processes, and societal practices, but also on the validity and viability of knowledge and societal changes that constitute what is deemed sustainable.

Within the broad heading of human dimensions of global environmental change and its attendant challenges, KLSC will address specifically the thematic areas of climate change, biodiversity loss, and resource allocation. In addressing these thematic areas, KLSC projects will also take a perspective and approach that cuts across the primary domains of research of other projects. That is, they will draw upon and contribute to many of the research projects in global environmental change, both within IHDP and other programs.

3.1.3 A core project with a cross-cutting theme

Knowledge, learning, and behavioral/societal change are important in many projects, but they are not the active focus of these projects. As a cross-cutting project, KLSC will be able to harvest relevant ideas and information gained in other IHDP core projects and partner projects – for example, Urbanization and Global Environmental Change (UGEC), Land and Ocean Interaction in Coastal Zones (LOICZ), Integrated Risk Governance (IRG), and Earth Systems Governance (ESG) - and will actively seek to engage with other projects to support their research and activities with lessons learned and insights gained in KLSC research.

KLSC recognizes the overlaps with other IHDP projects and will provide a platform for their interaction and exchange of insights on knowledge, learning, and behavioral or societal change.

KLSC will create a diverse community of people involved in connecting various sources of knowledge, forms and conditions for learning and applying that knowledge, and the drivers of and hindrances to societal change based on the knowledge and learning. The intention is to develop this community into a network for sharing the resulting insights about societal change for sustainability among themselves and with related networks. This includes scientists, politicians, learning and education communities, funding agencies, industry, NGOs, policy makers, United Nations University, UNESCO, and other international and interregional players that will mutually enhance use of lessons learned.

3.1.4 A reflective and iterative process of research and activities

As in other projects, KLSC will foster a process of continual reflection and iteration of learning to inform and improve its research. KLSC will do this not only through its scholarship, but also through action research projects that combine forming, testing, and evaluating hypotheses with direct interventions to effect the interplay between knowing, learning, and acting on the part of individuals and communities. In this way, the conceptual insights developed are tested directly and lessons learned in actual practice are fed back from experience in a diversity of real situations for further analysis and comparison.

3.1.5 Policy relevance and public-policy-science engagement

The project addresses several interrelated policy issues in society and as such, it is an 'extra-scientific' question of social science (Dreier 1997). The research can thus be conceptualized in the logic of Policy Science (deLeon 2003). It is problem-oriented, context dependent, process-related, normative, and trans-disciplinary. The first three conditions apply, as the perceived lack of adequate societal changes (problem) is studied in the specific setting of climate change (context) and with the focus on the levers and mechanisms of societal change (process).

In regard to the science-public-policy interface, the KLSC project addresses several key points articulated in the IHDP Berne meeting in 2006. These include:

The following statements from the Berne Summary are entirely consistent with the KLSC framework:

- "Enhanced understanding regarding the injection of scientific findings into the policy process…" This is an important area in which the KLSC project can examine the process through which knowledge is considered, understood and incorporated or discarded in developing policy to effect or reflect societal change.
- "Creation of new policy instruments and evaluation of their effectiveness in dealing with different environmental issues." It is the evaluation of effectiveness of policy that again overlaps with KLSC in that it asks whether the policy instruments are in fact instruments of change.

There is a growing body of literature about sustainability and policy responses in the form of academic studies, think tank reports, policy appraisals, and real world case studies. KLSC can ask whether and how it may be possible to make better use of this knowledge by developing new practices for engaging the public and policy makers with the knowledge and the process of producing and understanding the knowledge.

3.2 Perspective and scope

In this section we outline the perspective and scope of the research and action agendas for KLSC. On one hand, the project addresses the relationships between knowledge, learning, and positive, adaptive change and, on the other hand, identifies and probes the negative or resistive responses in terms of significant factors that decouple from actions or redirect knowledge to maintain stasis or produce maladaptive change as regards sustainability. The research is intended to identify different pathways, patterns, and dynamics through which knowledge and learning may contribute to behavioral change that furthers sustainability. We are also concerned with the extent to which factors can be identified across spatial, temporal, and sectoral dimensions of society, which could facilitate shifts towards more sustainable lifestyles. To the extent that pathways, patterns, and dynamics that promote and conditions that inhibit changes for sustainability can be identified, it may be possible to mobilize resources for the promotion of sustainability in more effective directions.

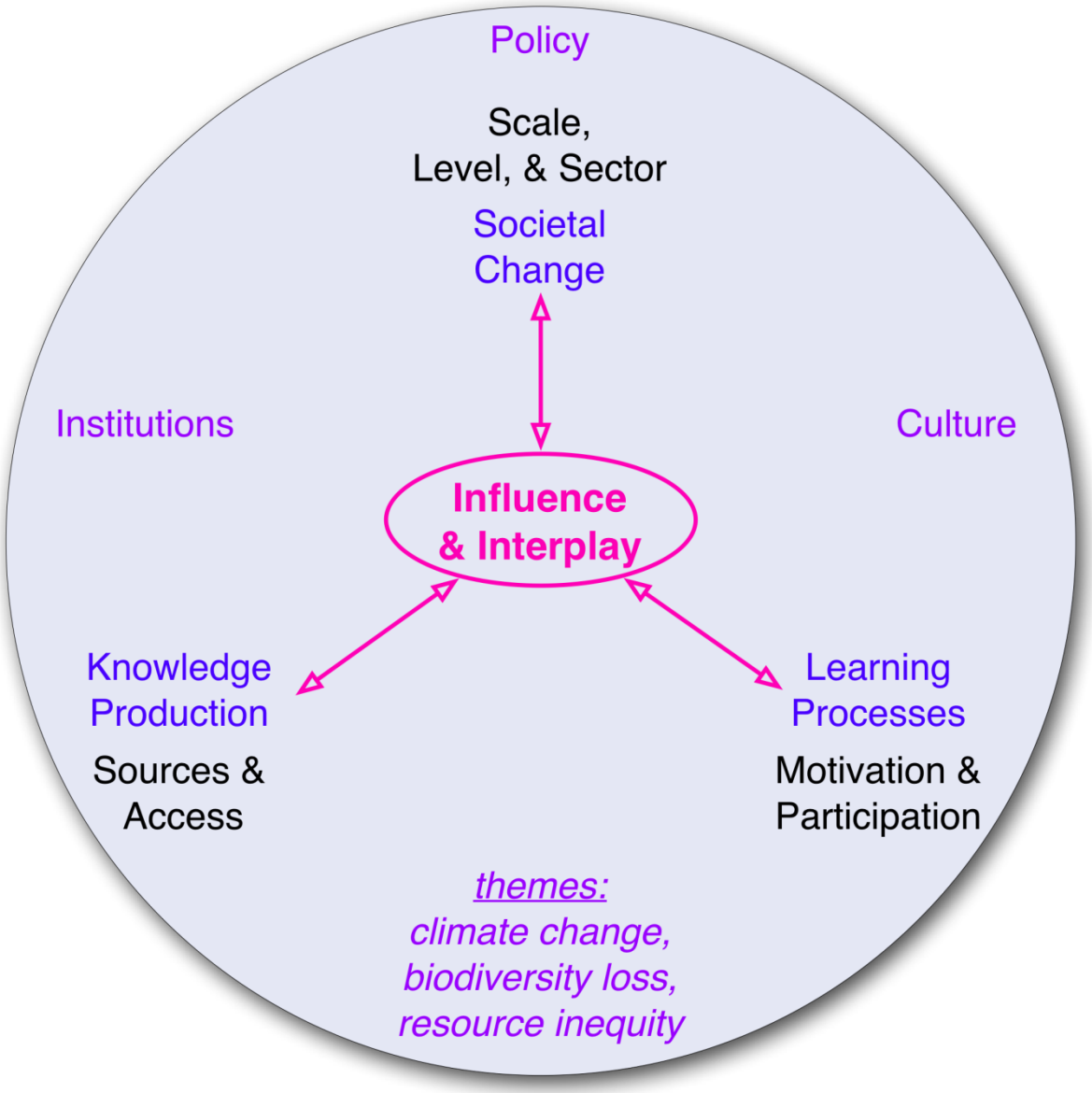
We can view the process envisaged in the KLSC program as a 'double loop' learning process. One loop is the process of learning from existing cases or conducting field experiments. The other is the reflection upon these lessons and deepening scientific insights through this reflection.

The questions will evolve as input from formal and informal experts, practitioners and policy-makers is collected. Some categories and questions overlap to some degree, indicating that the questions might be addressed empirically in different ways that may complement each other.

The schematic diagram below illustrates the central issue of linkages and mutual influences between the equally-weighted domains of knowledge production, learning processes, and societal change in the contexts in which the interplay

occurs and in regard to the three themes of particular concern and the particular aspects in each domain.

Figure 1: Influence and Interplay as the core issue for KLSC



What are the research questions and actions can and should KLSC as an international network of researchers and practitioners undertake to understand the patterns and dynamics of the interplay between the elements in the diagram?

3.3 Research Questions

There are three large categories of questions we want to investigate in considering the interplay between knowledge, learning, and societal change. One revolves around the relationship between environmental governance and societal

change. The second seeks to elucidate the basis in knowledge and understanding for decision-making under realistic conditions in diverse conditions and cultures. The third category is about the conditions needed to create greater individual and community or institutional capacity for change and adaptation.

In the first category, we want to understand the characteristics of and interaction between horizontal and vertical communication in multi-level governance processes related to global change. That is, how the existence and development of grass-roots movements in socio-economic, political, and cultural communities interact with levels of governance in linking knowledge, learning, policy making, and societal change. This then can become an avenue for examining mechanisms of scaling up or growth of movements or of their inhibition.

In the second category we ask what are the utilitarian and non-utilitarian factors and heuristics employed by individuals and communities or institutions that influence decisions and actions for or against change; how do these evolve over time as individual changes reinforce each other to aggregate into a substantive community or institutional change or how do they diminish each other to retard or block change? This can lead us to better empirical data needed for qualitative understanding of coupled social-ecological systems and better mathematical modeling of these complex systems.

The third category is about building capacity for social learning and adaptation. We will use case studies of successes and failures in knowledge production and use, learning and communication, and use the insights gained to develop and test strategies and tools to enhance learning and education that strengthens adaptive thinking and collaborative problem solving throughout the life span. This corresponds to the need to "develop understanding needed to create the conditions that enable effective adaptation decisions." (Patwardhan, et al. 2009).

There are many more questions that can be formulated within the intellectual domain of KLSC. More or less closely associated with each vertex of knowledge, learning, and societal change in Figure 1 are issues that should be explored and investigated to illuminate specific aspects of the central issues of influence and interplay among all three vertices.

3.4 Methodology

A project that is directed at strengthening interactions between diverse groups of actors depends very much upon the interest shown by the actors and communities involved. Not only do they need to become involved, but the practical main directions of the project will also be determined to a certain extent by the themes that are able to gain support (in kind, financial, etc.).

A project in which interaction between scientists and other actors is core should have a Steering Committee in which these varied backgrounds are reflected. The Steering Committee is charged with setting the short-, medium- and long-term strategic objectives.

A specific and important target of the project in line with the Berne strategy regarding policy relevance could be to build connections to and examine the IPCC and IPBES (Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services) processes. This may lead to broadening the scope of these processes to include more human dimensions into the assessment process and perhaps affecting the policy and agreement forming process. A possible route could be to start thinking about how to develop an additional assessment track, perhaps in conjunction with the Millenium Assessment of Human Behavior.

In addition to questions of sources and legitimacy, the matter of accuracy and certainty remains. An essential point is that full certainty and complete knowledge in matters pertaining to sustainability, as in other fields of science, is not now and will not in the future be available. A degree of uncertainty arises fundamentally from the nature of science as a process of forming and refining conceptual and operational models of the natural and designed universe. These models are part of an open, continually evolving understanding, not a fixed and closed body of knowledge (Tabara 2005).

The design of the methodological framework is obstructed by the lack of a closed theoretical foundation, the characteristics of the context and the actors, and by the interdisciplinary nature of the problem. Requirements and conditional factors are unclear or may change during the development process.

For such problems, literature suggests an evolutionary construction process, i.e. a course of incremental-iterative prototyping (Kargl 2000, pp.80-85). These so-called spiral models forgo clearly defined intermediate results, but allow for recurring phases of definition, design and validation. Starting with an initial configuration of goals, alternatives and context derived from the exploration, a prototype is designed and validated. Based on results or problems, the goals can be adjusted; and new theories and context variables can be in- or excluded. While the name 'spiral model' is taken from software engineering, the procedure as such is based on commonly used feedback theory and among others used in educational research. The advantage of using feedback techniques is that it solves the question of what comes first, the research or the hypothesis: Since the investigation is seen as a loop process, research can commence at any point to deepen understanding (Keegan 1996, p. 33). The theoretical foundation presented in Part II will be successively extended based on problems or gaps occurring in each cycle.

A distinctive element of the project is that it diverges from the usual operation of scientific projects, in that it is not starting from research and then looking for ways to implement the research results. The core of the project is to connect the various actors in designing ways to better connect various sources of knowledge for societal change. In this sense the project itself becomes a learning device about sustainability to bring about social change.

As has been discussed in an earlier chapter, action research is crucial in this cross-cutting project and will be employed to strengthen and expand the understanding arising from the project's complementary academic research efforts. This is an evidence based iterative process in that the assessment is used to improve the process, products, and outcomes in successive stages.

The academic science part of the project will involve science assessments, case studies, and theoretical framing and reframing activities, all of which will be communicated through the academic publication channels, though not to the exclusion of channels that make that knowledge and insight accessible to a wide range of stakeholders appropriate to the content.

The idea is that an important component of the entire project is to develop dynamic processes of co-creation of knowledge by diverse stakeholders with different competences and expertise at local, regional, and global scales (Rocchi, 2005). The experiences within such dynamics (be it developed in the course of systematic analysis of experimental approaches or case studies as part of the project, or otherwise) can then also be used for systematic reflection by the scientists involved and for implementation in new research and in educational activities. KLSC proposes an evolutionary perspective on knowledge, where applied practice and scientific expertise result from an accumulation of experience (Campbell & Stanley 1966). This iterative and transdisciplinary approach is referred to as action research.

Action research is a process in which researchers focus on an activity or behavior of a group or community of interest. The research team then guides or conducts the activity and collects data from it. The data is analyzed and used to draw conclusions, and, if needed, to design an iteration or alteration of the intervention experiment. In this part of the KLSC project, the objective is to develop effective collaboration between the research scientists, stakeholders in the domain of interest, and practitioners who engage with the stakeholders.

Conducting experiments is not the only road forward, however. It is also possible to systematically learn from activities that have already taken place, be it in conjunction between research and practice, or experiments in society in which research was not explicitly involved.

Workshops and brainstorming events – "thinkshops" - are essential mechanisms for reflecting, refining, and reframing the research of KLSC as the project evolves.

3.5 Outcomes and Contributions to the Grand Challenges

As the KLSC program builds a community involved in studying and catalyzing societal change for sustainability, what will be the products or deliverables of the project? The KLSC project should produce useful new knowledge, collect and make use of the wealth of existing insights, and bring these to bear in its core domains of climate change, biodiversity, and resource allocation. KLSC should produce and provide to policy makers, scientists, and the public(s) guiding principles and concrete examples of good practice for strengthening adaptive capacity in the core domains. Of course, given the complexity of the challenges and the wide range of often undetermined local conditions, the guiding principles will vary significantly depending on the specific issue involved and the cultural context. By the same token, the form and delivery mechanism of the guidelines and examples will have to be appropriately tuned to the particular culture, conditions, and concerns of the recipients.

ICSU Visioning:

1) "How can improved scientific knowledge of the risks of global change and options for response most effectively catalyze and support appropriate actions..." This is central to the concept of KLSC.

Belmont Challenges

2) "Develop and deliver the knowledge required to address pressing global to local environmental and societal issues." KLSC takes the view that delivery is generally insufficient without real participation by stakeholders and that is the basis for the engagement with stakeholders planned for KLSC. It also motivates KLSC research into the relationship between participation and agency by stakeholders.

3) "Identify the objectives and means for effective translation and communication of scientific knowledge for targeted sectors and regions in order to realize the intended benefits from the application of such knowledge" One focus of KLSC is on the process of co-production of knowledge and the relationship between that process and the understanding and use of that knowledge in behavioral and societal change.

4) "Nurture the next generation of experts." Nurture not only the single next generation, but lay the fundamental groundwork for problem based, trans-disciplinary learning for successive generations and all members of society, including experts. KLSC can contribute substantially to the process of learning for change by applying the emerging knowledge of KLSC and others to lifelong learning starting in preschool and continuing through all educational levels and beyond (EPSD 2010)

4 The KLSC Roadmap

4.1 Activities

Overall, the plan for research and action consists of the following elements:

- form a broadly-based and extensive community of practice involving researchers, practitioners, and stakeholders,
- conduct academic research to illuminate the fundamental scientific issues of KLSC and relate it to existing conceptual frameworks in a wide range of intellectual domains,
- with individuals and groups in academia, local communities, corporations, the polity, and civil society, develop and conduct action research experiments, design experiments, and simulations,
- on issues relevant to KLSC, maintain on-going assessments from a KLSC perspective of research programmes, projects and policy in relation to the Grand Challenges in Global Sustainability Research,
- analyze the various forms of resulting data with a view to its representation, accessibility, and its use and usability for action and

societal change

- synthesize the results of the analyses and assessments and communicate them to KLSC project partners, the wider scientific community and science-policy-dialogues and as information to guide development of KLSC projects,
- produce and make available via a variety of appropriate channels various forms of output strategies, products, and methods designed to influence thinking, attitudes, and practices to catalyze change toward sustainability, and
- assess the impact of KLSC research and outcomes of the products.

4.1.1 The KLSC WIKI

As outlined in chapter 2, a bewildering variety of terms is commonly used discussing concepts and approaches around knowledge, learning and behavior. Definitions may describe synonymous, independent, overlapping or even contradictory features. Some terms, like "independent learning" reflect more the cultural approach of an author, rather than conceptual proximity.

The KLSC wiki will be a web-based tool to capture relevant information in all its variety and make more accessible what knowledge exists and improve the shared understanding of it.

In this regard it will be crucial to include sources in addition to the formal scientific literature. It is essential for the diverse community of practice and research characteristic of KLSC that "grey literature" and informal materials produced by practitioners are integrated into the wiki with appropriate attributions.

Explanation what is meant by terms like learning; knowledge, or sustainability is crucial to link goals and policy intentions to practical procedure. Failure to define, reflect, and explain terms leads to negligence of whole domains and existing research connected to them. It may prevent the incorporation of valid scientific findings to enhance initiatives, even in quite fundamental areas. In part this reflects a general problem of applied social sciences and policy making. Political debate focuses on the identification of problems in a specific context, while research focuses on in-depth understanding of a specific problem.

It can be hard to reconcile academia and practice in general not because of the guiding questions, but because of the difference in the thinking guiding the work: Academics work in what is called the 'belief mode', testing knowledge and logic of reasoning, and reacting to new ideas by collecting arguments supporting or rejecting it. Professionals work in a 'design mode', testing utility, situational fit, or growth potentials, and reacting to new ideas by searching for applications or improvements. (Reinmann 2005) The value of findings for general application is hard to judge without knowledge in what 'mode' it was written.

Addressing these discrepancies and developing a common working base through the KLSC wiki will help the diverse communities of research and practice

associated with KLSC, as well as providing a basis for communication more widely.

The wiki and associated web resources will serve to cross reference and connect with the activities, research, funding status and prospects, and community members of KLSC.

4.1.2 Global and regional workshop and forum series

Workshops are envisioned as critical for development of the KLSC project. First and foremost, a set of workshops will be held to structure KLSC research and develop pilot and flagship research projects addressing the core research questions through the KLSC influence and interplay lens. There will be an initial international brainstorming workshop in April 2011 in Switzerland to further establish the initial set of research efforts within the KLSC framework and equally importantly, to begin the process of developing a research, practitioner, and stakeholder community around KLSC issues.

Engaging a wider community through a variety of traditional methods and evolving digital media is an essential part of the project. In addition to face-to-face workshops, KLSC will test and employ forms of virtual fora in which issues can be explored and discussed synchronously or asynchronously among sub-groups or all interested stakeholders.

Subsequent to the initial workshop in April 2011, a series of two to three workshops per year will be held. The workshops will focus on particular research targets and themes within the KLSC science plan. For example, one workshop might be on Workshops will be conducted with short presentations by a few researchers, practitioners, and stakeholders to set the frame for intensive discussion on concepts, methods, language, results, interpretation, and engagement of a wider community with the outcomes.

Some of the workshops will have a regional focus and be hosted in regional centers. These will address the issues, research, and actions of regional practitioners, policy makers, industry, and researchers.

KLSC should plan to take advantage of major international global change meetings at which the project can present its on-going work and attract new members to the community of practice and open new leads for funding. One such event is already on the near horizon in March, 2012, when the conference on "Planet Under Pressure: New knowledge towards solutions" will be held in London, UK. This will be an opportunity for KLSC to make an initial presentation of its approach to cross-cutting issues and preliminary findings that relate to the work of IHDP and other global change programs who will be present.

Further workshop series can be envisioned to support the objectives of integrative and cross-cutting research. As global change research in general moves towards increased policy-relevance, actionable issues to which KLSC can contribute, such as multi-level stakeholder governance of fisheries or insurance coverage for low probability, high risk conditions. In this regard the KLSC project is positioned to provide a critical cross-cutting function, as issues at the interface between the projects knowledge production and political action form the core

concern of the KLSC research agenda. Options to providing complementary insights around such cross-cutting topics through targeted workshops will thus be further explored.

4.1.3 Narratives of visions for the future

In what way and to what extent can the clear articulation of a positive vision for the future stimulate societal changes for sustainability? We use the term "visions" as a depiction of a different future than a business-as-usual trajectory that may help guide action in new directions. The assumption here is that due in part to the complexity of information about sustainability problems, the creation and expression of compelling, simplified - but not simplistic - visions accessible in forms appropriate to each of the wide spectrum of communities may be necessary for stimulating action. Future visions may have to do with sustainability technologies (non-fossil fuel automobiles, LED light bulbs, geothermal power), policies (the wide scale introduction of policies to promote renewables, recycling and reuse), new strategies and methods for education that fosters understanding and practice for sustainability, or innovative approaches to creating synergy between environmental and economic concerns.

The movie "An Inconvenient Truth" does not deliver a new story. But the fact that it was being told by former US Vice-President Al Gore helped to legitimize, among other things, the message being told. When movie stars or other famous people, such as Prince Charles, put their support behind sustainability causes, it can help spread awareness among large segments of a population. Even without the cachet of an existing name brand, people can become catalysts for others to act by capturing their attention with creative events and actions.

It follows that it may also be important to examine not just the extent to which future visions matter, but also the extent to which different visions are understood, shared and trusted by different actors and societies. How much agreement is there and does there need to be (and at what level) a common understanding about what a future of greater sustainability can, might, and perhaps should look like?

How visions are expressed or encapsulated through artistic media, including dance, music, poetry, drama, and prose is an important aspect of KLSC. The expression of ideas through emotionally connective forms that resonate in different ways in different communities and cultures can also have a significant effect on whether and how the ideas are perceived, understood, and ultimately accepted or rejected and thus on decisions for or against action. In this, the involvement of artists and humanists in KLSC may help greatly not only in engaging diverse communities in the ideas and activities, but also in understanding the role of different forms of expression of visions.

4.1.4 Capacity building for KLSC research

The scientific planning committee proposes that in order to conduct this project successfully and in accord with the objectives of the ICSU Grand Challenges and the IHDP Strategic Plan 2007-2015, the purpose and scope of this activity requires the inclusion of the perspectives, knowledge, and participation of local actors, practitioners, and stakeholders. Therefore, the project can best be

developed from the perspective of *community building*: building a diverse community of research, learning, and practice intent on co-creating knowledge in order to better learn how to address the issue of mitigating and adapting to global environmental change.

In addition to contributing to the IHDP capacity building workshops, KLSC will also provide on-going mentoring and collaboration, primarily *in situ*, with young and established researchers in developing countries who are interested in working on projects within the KLSC umbrella. The KLSC project at the international and regional level will seek to raise funds for small seed grants to support the preparation of competitive research proposals in the KLSC framework by researchers in developing countries.

4.2 Deliverables

The expression of the outcomes of the project can take different forms, such as blogs, guidelines, the KLSC wiki, communications media, interactive games, educational materials for multiple levels of formal and informal learning, summaries of successful practices and cautionary tales, and white papers. The traditional path of academic journals and books will be a major useful outlet for the knowledge and insights gained by KLSC that will be complemented by an expanding use of other media.

The project will use the new social media, which is increasing important and, for many people has become a primary means of knowledge transfer and learning. The widespread use of cell phones, and the rapid development of games and specialized information sources in them, offers new and powerful forms of communication. Because these are interactive media, they offer a direct mechanism for increased engagement and participation, rather than relying on traditional forms of dissemination. At the same time, the feedback inherent in these interactive media can provide a valuable research tool to understand the role of the medium itself in connecting knowledge, learning, and change.

At the same time, this technological avenue may not reach many individuals and communities that do not have readily available or adequate internet access. Some communities that are otherwise quite isolated, now have cell phone connections. The cell phone has already led to new communication and action initiatives.

An important vehicle for helping KLSC reach different communities with the evolving insights and strategies for action is through art of various forms. The narratives mentioned earlier are both input as expressions of visions and output as ways of communicating the ideas developed by KLSC projects. By engaging with artists working in different media and cultures, the community of practice that is KLSC is richer within and more communicative with other communities.

Multiple approaches for research and outreach to share the insights and expand the value gained from this project will be used. KLSC will distribute through multiple avenues and share its findings, the outcome of its work is also a means to enabling further learning, rather than just knowledge transfer. The project will

seek to use media technologies to enable the findings and outcomes to be contextualized and used in context.

The core of the project is generating a new community of learning and practice. Therefore outreach activities are at the heart of the project. It is clearly essential that the community generated by the project becomes an effective central forum where social and natural sciences, humanities, and artistic expression meet and connect for collaboration on research and actions. The KLSC project then will serve as a platform on which the evolving research and practice can foster learning among diverse stakeholders on how to better design change processes for sustainable development.

4.3 Program Offices and organization

4.3.1 International Project Office and Regional Offices

KLSC plans to have both a central international project office (IPO) and one or more regional offices. The IPO will be the central hub which will

1) organize operations for the project as a whole, including meetings of the Scientific Steering Committee and advisory groups,

2) provide the necessary infrastructure, including maintaining web services, coordinating publications, and maintaining budgetary and meeting records,

3) facilitate communication among the KLSC network and with the other IHDP and Global Change programs.

An scientific officer located in the IPO will be responsible to the SSC and, with an operations officer, will coordinate scientific and SSC meetings, will seek funding in collaboration with SSC members and the IHDP Scientific Committee, write proposals, and maintain a website and use various media to communicate with other projects within IHDP and the global change research and action communities.

The IPO will be established soon after formal approval by the IHDP Scientific Committee and official launch of the project. The location and funding for long-term operation of the office are currently being discussed with interested institutions.

In addition to the IPO, regional offices will be established over time. Several potential collaborating institutions in Asia, Africa, and Latin America have expressed interest in hosting a regional office. These regional offices will serve several key roles in organizing capacity-building workshops and mentoring, regional workshops on research and action, building a regional coherence among the KLSC community of practice, and supporting the IPO and SSC in seeking funding from regional resources. Opportunities for regional assessments and regional projects will be explored, both as stand-alone activities and in the form of regional foci within global KLSC research questions. Collaboration with regional

offices in designing the KLSC Wiki and KLSC products to serve regional needs will be sought to increase the overall value and impact of KLSC deliverables.

4.3.2 Affiliated institutions and communities of practice

The existing project portfolio of the Global Change Programmes provides a rich source of experience and best-practices for scientific collaboration. For example, the Global Land Project (GLP) and the Earth System Governance Project (ESG) have pioneered systems of regional research nodes, and affiliated institutions and researchers. The Population-Environment Research Network (PERN) has successfully established virtual research communities. The KLSC project will seek to explore and adopt such best-practices and adapt them as required to address issues and gaps identified in the existing models by the ICSU Visioning process.

KLSC will furthermore seek to establish modes to interact with established communities of practice and established research networks. The three focus topics (climate change, biodiversity and equity), as well as the three 'cornerstones' of the KLSC interplay concept (knowledge production, learning, and societal change) are all addressed by specialized research groups and communities of practice. Using the insights of such groups to full effect for KLSC research, but also identifying critical issues in specialized research by KLSC outcomes poses both challenge and rich opportunities.

4.4 Milestones

The initial milestones for KLSC are listed below. These will be refined and filled out in and after the KLSC workshop in April, 2011.

February, March 2011: external review of the draft science plan

March or April 2011: submission of science plan with reviews and responses to the IHDP Scientific Committee

April 2011: first KLSC international workshop on the science plan and development of initial projects

May 2011: approval of the science plan by the Scientific Committee

June-August 2011: secure funding for, hire a scientific officer and project coordinator for the International Project Office (IPO), and set up the IPO.

August 2011: hold organizing workshop for specific project(s) under KLSC auspices.

September 2011: report to IHDP Scientific Committee on the current status and immediate future activities of KLSC

November 2011: secure funding for a regional office, hire regional manager, and host a regional workshop around a project group or concept.

December 2011: KLSC workshop in preparation for the conference, Planet in Peril to be held in March 2012.

March 2012: presentation of panel session(s) on KLSC projects at the IGBP conference in London, UK.

March 2012: KLSC international workshop in conjunction with the Planet in Peril conference – planning for the next stage of projects, activities, and collaborations

May 2012: first capacity building workshop around a KLSC theme in regional office

September 2012: report to IHDP Scientific Committee on KLSC activities and projects

NOTE: These milestones and subsequent ones will be further delineated following the April 2011 international workshop

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