UJ Sociology, Anthropology & Development Studies

W E D N E S D A Y S E M I N A R

Hosted by the Department of Sociology and the
Department of Anthropology & Development Studies

UNIVERSITY OF JOHANNESBURG

Meeting 5/2009

To be held at 15h30 on Wednesday, 4 March 2009,

in the Anthropology & Development Studies Seminar Room, DRing 506, Kingsway campus

‘Resilience Thinking on the Natural and Social Science Knowledge Schism’

Presented by Karen Nortjé and Nikki Funke

Council for Scientific and Industrial Research

- Please do not copy or cite without authors’ permission -

- Programme and other information online at www.uj.ac.za/sociology -

Resilience Thinking on the Natural and Social Science Knowledge Schism

Sherwood, L, Funke, N, Nortje, K, Van Wyk, E

Introduction:

There has never been a greater need for engagement with the concept of resilience thinking than at the present moment. This is because knowledge systems are exhibiting shortfalls in coping with the complex social-ecological problems[1] that the world faces today and in achieving sustainable development imperatives. Knowledge systems are understood to be the systems in which the natural and social sciences reside and are comprised of scientists from various fields of study within these disciplines who engage in scientific inquiry in order to learn more about the natural and human world. An alarming number of scientists at the United National Intergovernmental Panel on Climate Change highlight the gravity of the socio-ecological situation the world currently finds itself in. As a result, the task of crafting a policy response to this multifaceted challenge requires integrated, trans-disciplinary and flexible knowledge systems. At present, there is a need to manage our social and natural science knowledge systems (Chartrand, 2002), and fill in gaps where capacity to respond to the complex knowledge demands posed by global climate change is weak.

In this paper we suggest sustainable development has created new and pressing knowledge demands which our current knowledge systems can not adequately address. We propose the application of a resilience approach (Walker, Salt, 2006) to knowledge systems as a way of interpreting the evolving relationship between them over time, how they currently relate to each other and what can be done to overcome some of the obstacles to integration between them. Furthermore, we use resilience thinking to expose the risk associated with high levels of knowledge specialization and a lack of interconnectivity between the natural and social sciences required to solve the complex human-environmental problems of today. Having applied resilience thinking to determine the *status quo* of the relationship between the two knowledge systems, we use interviews to link the theoretical need to integrate knowledge with 'on the ground', everyday experiences of practicing social and natural scientists, to demonstrate where current queries and opportunities for integration lay. The interviews reinforce a broad recognition that knowledge integration is needed, and highlight the challenges to doing it, as well as some pragmatic lessons learned on what works. An attempt will further be made to elucidate some key ingredients to successful scientific integration by providing a case example. This case example takes the form of a researcher's reflections on the dynamics among a group of scientists working on a conservation project and offering some generic tips applicable to a range of scenarios where knowledge integration is needed.

[1] Worldwide, humans have converted one third of the land area to agricultural and urban use and most of the remainder is too dry for agriculture. Global grain production will need to increase by forty percent to meet demand by 2020. Sixty percent of the atmospheric concentration of carbon dioxide since 1750 has taken place since 1960, attributable to fossil fuels and land use changes and capture fisheries and fresh water, vital ecosystems, are beyond levels that can be sustained at current levels, let alone future ones. One quarter of commercial fish stalks are over harvested. Freshwater usage exceeds long term accessible supplies while ground water supplies are already over drafted (Millennium Assessment (2005)

Resilience Thinking on Knowledge Systems

Resilience is a concept anchored in the ecological sciences, but is equally useful as a "metaphor" in describing what happens when shocks or disturbances occur and in this context, those related to global climate change, be they natural disasters, health crises or social economic upheavals. In ecology, resilience refers to the capacity of a system to absorb perturbations from, for example, climate change and system wide changes arising from economic development as well as the capacity of the system to re-build, renew and reorganize afterwards (UNESO, 2007). Loss of resilience can cause rapid transitions or shifts into qualitatively different states and configurations with consequences for people, ecosystems, knowledge systems, or whole cultures. The use of the resilience concept is now rapidly spreading to social sciences, policy and business.

The value of using a resilience approach to interrogate poorly integrated knowledge systems, which subsequently are unable to meet current knowledge demands, can be illustrated by a quote from anthropology. "Resilience studies pursue knowledge of how systems respond to change and how to prepare for future change (Nelson, 2007). In this case then, we use a resilience approach to indicate how the relationship between the knowledge systems has responded to change over time, how the two knowledge systems currently relate to each other and how, from a practical perspective, some of the obstacles to their integration can be overcome, in other words, how they can prepare for future change. Resilience thinking highlights the risks of purely technical, highly specialized solutions for a problem within a part of a system, and demonstrates that a holistic approach to knowledge is needed to address the interconnected nature of the challenges facing the scientific community.

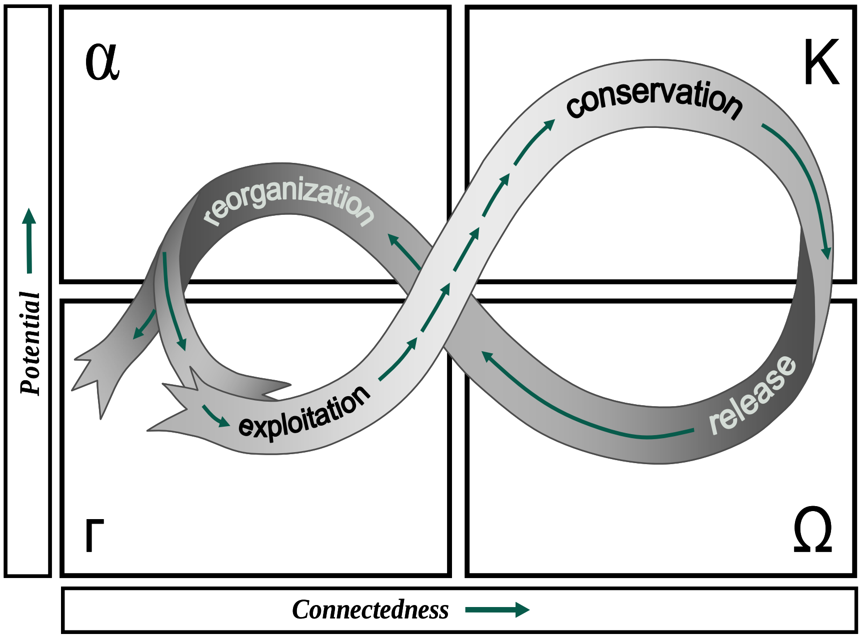
While the notion of resilience was developed around ecological systems and is being increasingly applied to social-ecological systems, we posit here that knowledge systems behave similarly to complex social systems and have the same attributes: interconnected parts, feedbacks, non-linear behaviour, surprises and delays inherent in the feedbacks (Moberg and Galaz, 2005). If knowledge systems are to be resilient, in other words absorb disturbance, undergo change and retain the same identity with its former functions, structures and feedbacks (Walker, Salt, 2006:32), they will have to continually refine their existing ideas, develop new knowledge, and demonstrate a willingness to engage in transdisciplinary. The need to realise sustainable development objectives coupled with the challenges presented by global climate change are a source of external stress to current knowledge systems. Therefore, the development of a knowledge base rooted in flexible, adaptable and integrated ways of "knowing" is of prime importance.

In addition to resilience, there are two other key terms relevant to resilience thinking that need to be clarified at the onset. The first is potential, which describes the development possibilities of systems (Gunderson and Holling, 2002; Burns, 2007) and controls the number of alternative options that are open to a system (Holling, 2001). In this instance, a knowledge system with high potential, as a result of increased efficiency is able to develop in a cultural or social sense due to high degrees of interconnectedness between different fields of study within the natural and social sciences and considerable access to its social resource bases. This could take the form of rich and interesting study material, well-funded research projects, ground-breaking natural or social scientific discoveries, an ability to communicate research and, where applicable, use it to improve society and contribute to sustainable development, and a well-established, accredited, supportive, open-minded and organised scientific community. Importantly, the realisation of a knowledge system's potential is determined by the influence and actions of those who control it, in this case natural and social scientific associations or organisations.

Secondly, connectedness is defined as the strength of internal connections that mediate and regulate influences between the inside processes of a system and the outside world. It is therefore linked to the degree of internal control that a system can exert over external variability (Gunderson and Holling, 2002). High levels of connectedness within a system, in the form of mutually supportive relationships between actors, can increase resilience as long as scientists are willing to cooperate with scientists from other disciplines, even if this is not a prerogative for all research that is conducted. Such cooperation may increase the opportunity for scientific research to develop solutions for complex research problems that do not necessarily fall within the bounds of a single discipline. However, as soon as this connectedness takes the form of rigid intra-dependencies, within either the natural or social sciences, and scientists begin to gravitate towards working within "silos" and reject the idea of working across disciplines, the resilience of the system decreases. Excessive self-reliance does not necessarily offer the kinds of innovative solutions needed for many of the problems facing the world today.

In order to apply resilience thinking to the two knowledge systems identified, we make use of the metaphor of the "adaptive renewal cycle" (see Figure 1), which is closely linked to resilience theory and is a schematic representation of the phase states through which many systems, including business, political, ecological and social cycles evolve in response to external and internal controlling variables. The external controlling variable is understood to be global climate change. The various phases of the cycle accommodate the potential for novel changes within the knowledge system composition, structure and functioning. Although the concept of the adaptive renewal cycle originated within the field of ecology (Holling, 1986), it is increasingly being applied as an analytical framework for business leaders, policy makers, resource managers and politicians, and people who deal with risk in a complex world (Carpenter *et al.*, 2001; Folke, 2006). In this case, it is used for the analysis of a knowledge system-based case study. A key element of complex adaptive cycles is understanding that managing a system by its individual components may be quite successful in the short term, but will lead to problems in the long term. Resilience thinking offers a process-oriented way of understanding the world and managing knowledge resources to produce different knowledge states. It offers a useful way of conceptualizing systems and when state changes are most likely to occur. Learning is based on a complex process of continuous change within cycle of unfreezing, changing and refreezing (Schein, 1995).

Figure 1: Four Phases of the Adaptive Renewal Cycle



The exploitation phase of a system's adaptive renewal cycle is characterized by exploitation of all possible niches, for example, an entrepreneur who succeeds in starting a new business venture. During this phase, the components of the system are weakly interconnected and its functioning is regulated more by external, rather than internal, controls. System potential during this phase is generally low (Walker and Salt, 2006). During the conservation phase, energy is stored and materials slowly accumulate as the system's potential increases. System functioning also becomes increasingly internally controlled as a result of a high degree of internal connectedness in the form of supportive relationships between specialists, the main actors in this phase (Burns, 2007; Walker and Salt, 2006). In a growing business, this phase is usually characterized by increased specialization and efficiency (Redman and Kinzig, 2003). While this phase can be very beneficial, it also poses risks as connectedness increases, it creates a dependence on existing structures and processes. In the case of the knowledge systems, in which the natural and social sciences are embedded, reliance is formed on existing knowledge, its traditions and established approaches to problem-solving. Specialized knowledge which exists in isolation from other forms of knowledge contributes to fragmented and static ways of knowing. This can cause the system's growth rate to slow and impede its ability offer innovation when the world around it changes, an especially when those changes occur rapidly. As a result its resilience declines; it becomes increasingly rigid and is also more susceptible to disturbance (Burns, 2007; Walker and Salt, 2006).

The transition to the release phase can happen in an instant and the longer the knowledge system was in the conservation phase the smaller the shock needed to end it. A shock can be a knowledge need that the knowledge system cannot adequately address and triggers the system's weak resilience capacity during the late conservation stage to break apart its reinforcing relationships. Resources which were tightly bound are released and the regulatory controls weaken (Walker, Salt, 2006:77) There is a loss of structure as the linkages are broken and knowledge capital leaks from the system.

This phase is often referred to, borrowing Joseph Schumpeter's term, as "creative destruction" where all things come apart, but reform in new, intelligent and novel ways (Schumpeter, 1950). This is the phase where innovation begins to show results and produce new feedbacks into the system, reinventing a new stable state of knowledge. The final phase is the reorganization phase, which is chaotic and governed by uncertainty as all options are open. It is governed by a drive for reorganization and renewal while small ideas and chance events have the ability to powerfully influence the future. Invention, reassortment and experimentation rule. The new knowledge actors are established and the end of the reorganization phase is the beginning of the rapid growth phase where new identities are formed (Walker, Salt, 2006:78).

Knowledge Systems within the Adaptive Renewal Cycle

The theoretical basis of resilience theory and the adaptive renewal cycle are explained above. Now we move on to mapping knowledge systems within the adaptive renewal cycle and resilience thinking is utilized to inform the risks associated with high levels of knowledge specialization and the presence of an external disturbance threat. During the exploitation phase, knowledge formed within the humanities taking the form of theology and philosophy, which branched off into separate knowledge groups (Chartrand, 2002) with low levels of interconnectedness within and between them thereby exhibiting low levels of potential. The exploitation phase was characterized by people, or "knowledge entrepreneurs", who exploited all opportunities and niches to develop and further the fields of study within their knowledge system. Among these individuals were Plato and Aristotle (pre-Christian), as well as Descartes, Pierce, and Bacon, who developed new knowledge resources and capacity. The Age of Enlightenment was triggered by the spectacular successes of Galileo's and Newton's physics (Mukunda, 1999). The natural physical sciences, first developed in the 17^{th} and 18^{th} centuries, entered a period of rapid growth as new instrumentation for measurement and methodology for validity were developed. As new knowledge emerged, it was fragmented into manageable parts (Biswas, 2004). In due course, the social sciences grew from the natural sciences, which in turn had arisen from the humanities. The first social science subject to develop was economics which triggered the relatively rapid development of other social science subjects such as sociology and political science. The natural sciences were sub-divided, initially into physics and chemistry and later into life and biological sciences (Biswas, 2004).

Knowledge systems, having passed through the exploitation phase, and now formally divided into natural and social sciences, incrementally moved into the conservation phase. As fields of study became increasingly specialized, and the scientists working within them formed stronger bonds with their fellow scientists, levels of connectedness and potential began to increase. While such intra-connectedness within fields of study has proven to be beneficial in many respects, for instance enabling expertise within subjects from different perspectives, but there are also distinct disadvantages to high levels of specialization and a lack of interdisciplinary cooperation. As the respective knowledge systems' parts become highly interconnected and strongly regulated within this phase, growth and innovation slow as new ways of doing things are resisted and consequently the system becomes more rigid and resilience decreases. Flexibility is the price paid for increased efficiency as the system becomes increasingly efficient and redundancy eliminated. The result is a growing dependence on existing isolated knowledge structures and processes which render the system vulnerable to disturbance.

Such a system is increasingly stable, but over a decreasing range of conditions (Walker, Salt, 2006:77).

It is important to take a moment here and highlight the problem with high levels of knowledge efficiency and optimization according to resilience thinking. Current "best practice" is based on optimizing components of a system in isolation of the rest of the system and it is proving inadequate to deal with the complexity of the world and the multi-faceted challenges of sustainable development. Optimizing knowledge in the natural and social sciences means restricting the approach to a problem to an established epistemology and methodology to explain and understand a particular phenomenon. Optimization does not work as a "best practices" model because this is not the way the world works. The more elements of a complex knowledge system are optimized for some specific goal, the more that system's resilience is diminished. The drive for an efficient optimal state has the effect of making the whole system more vulnerable to shocks and disturbances, which is anything that breaks apart the web of reinforcing interactions and usually are externally motivated. (Walker, Salt, 2006:9).

The paradox is that while optimization is in theory about efficiency, it is only applied to a narrow range of values and a particular set of interests. The efficiency problem is that too much specification produces gaps and fails to quantify things of value which are increasingly important in sustainable development policy and planning. It is important to distinguish that it is not efficiency itself that is problem, *per se*, but when it is only applied to a narrow range of values and a particular set of interests it sets the complex system on a trajectory that produces undesirable outcomes (Walker, Salt, 2006:7). Sustainable solutions to our growing resource and environmental problems must seek an answer beyond the "business as usual approach" and apply new models of transdisciplinary knowledge to meet the nature of the problem.

While natural and social science knowledge systems are quite robust at present (Giampietro 2004:234; Anderies *et al.,* 2004t), their resilience to an external disturbance is decreasing. Global climate change and sustainable development imperatives have presented the knowledge community with a disturbance threat challenging the specialized and deeply ingrained ways of "knowing" within the social and natural sciences. Therefore, since the need to integrate the two knowledge systems in order to meet the social-ecological challenges of the future is largely recognized, the objective lies less in finding some way to form a "fusion" between the knowledge systems, which may perhaps dilute their strengths, but rather in how to encourage contributions from diverse disciplines within an integrative knowledge framework. It is important that such a framework should be embedded in a world view that recognizes and exposes the coupled and dynamic social-ecological issues associated with economic development.

Case Interviews: Opportunities and Pitfalls for Successful Integration

Recognizing theoretically that knowledge systems need to be integrated and that current specializations in divergent systems leads to rigidity as well as an incapacity to address complex socio-economic and ecological is one part of the equation. The other is to root it in some concrete and practical examples of the recognition and to identify what the challenges to integration are and provide some strategies of how to overcome them. Comprehending the path that will lead to new ways of thinking and conceptualising the world, its people and environment begins with understanding the way in which the practitioners of science invent themselves, their research and their scientific community within the context of science. In order to do this, the researchers involved in this project interviewed a variety of scientists. These interviews included those who generally see themselves as natural scientists and social scientists, as well as those who classify themselves in more focused terms, for example as bio-physical scientists, ecological scientists, applied scientists and Development Studies practitioners. It is important to note however that the majority of people interviewed felt comfortable with being called 'scientists'.

The definition of what a scientist or science is often led to a discussion of methodological practice. For example, science is *"the systematic and structured investigation of a problem"* (aquatic ecologist[2]); "*a logical process that is followed to generate new knowledge or understanding on a particular topic or issue*" (ecological scientist). For natural scientists, ideas such as predictive capacity, openness, universality and repetition are essential to the scientific process. Those identifying themselves as social scientists challenged many of the ideas put forth by the natural scientists and argued that flexibility both in theoretical application and methodological inception is needed for good science to take place. Often social scientists reacted very defensively to the question of whether or not they see themselves as scientists, for example one anthropologist said *". . . let them prove that I am not a scientist or that my work is not science!"* The reason for this is, these scientists argue, because they feel they constantly have to prove that they are in fact scientists, and that their work is valid and applicable.

The idea that science is a continuum was highlighted in several of the interviews, primarily by those scientists who identify themselves as having the capacity to work both with and as natural or social scientists respectively. In this way, it is easier to create a space for themselves in the world of science, which has been (as is indicated in this paper), very much domain driven in the past. These scientists argue that it is the tendency to claim scientific domains that has created many of the problems we face both in terms of issues related to development-related and environmental problems today. All scientific disciplines can be plotted on this continuum of science and scientists. It is interesting to note, however, that those who argued for a continuum of science nonetheless have different ideas about the practice of science and approaches to scientific research. Some, for instance, said that the continuum of science means that *"there is no single approach to science"* (applied scientist), while others argued that only the kind of science that adheres to the principles of predictive capacity, openness, universality and repetition can belong on this continuum. This difference of opinion shows that there is no consensus about which types of science belong on the continuum of science and therefore suggests that the continuum itself may described as "exclusionary", only accommodating the type of research that is conducive to a specific, rigid (and seemingly natural science based) definition and understanding of what science is.

Regardless of whether or not scientists subscribe to the idea of a continuum and regardless of the criteria they believe determine whether or not one's scientific discipline can be mapped on it, all the people who were interviewed mentioned the question of language. For example:

---

[2] Please note that the labels for the different kinds of sciences used in this chapter are used as they are identified by the scientists interviewed.

> *What makes working in multi-disciplinary projects easier is listening, making sense of what is being said and responding. Also, trying to understand why someone else says something particular. This means you have to suspend your own belief system and listen with empathy, wanting to understand what others tell you.* Natural scientist specialising in applied limnology.
>
> *Social scientists have to learn that if they want to work with natural scientists it is they who have to learn the language of the natural scientist.* Social scientist.
>
> *. . . the problem is one of translation that needs to take place for scientists from different disciplines to better understand each other.* Bio-physical scientist.
>
> *If they don't understand you they switch off.* Development Studies practitioner.
>
> *Several characteristics are needed for scientists from different disciplines to work together. The first is a common language/understanding that needs to be developed.* Applied scientist.
>
> *You have to learn their language – use their own language against them so they understand you are not –stupid.* Social scientist.
>
> *The challenges involved with doing multi-disciplinary work is one of language, especially when it comes to working with teams from other organisations, who often use the same concepts but have different meanings for them.* Ecological scientist.

It is clear that these scientists speak from experience as a result of having had to work with other scientists from different disciplines. Successful multi-disciplinary projects therefore require scientists to "*suspend their own belief system*" in order to be able to hear what others are saying. This, however, is not an easy task and many have experienced working on multi-disciplinary projects in a negative way. In this regard, for instance, social scientists often highlight the fact that they feel they have to be the ones who compromise the most. The above-mentioned comments made by social scientists illustrate this sentiment. While they recognise the need to learn the language of the natural scientists they have to work with on a particular project, they nonetheless feel that the natural scientists involved are not making a similar effort. A specific component of the problem is that social scientists often find themselves as a small minority among a large group of natural scientists who are working on a particular project. A senior professor in anthropology, for example, illustrates this point by saying, *"I have been working in the medical field as an anthropologist/ social scientist for the past 20 years and still I am usually the only one [social scientist] and have to constantly prove my being there and why my skills are needed".*

Difficulties when it comes to speaking the same language and understanding one another are not only problems to be solved by natural and social scientists. Funding agencies too have been identified as entities in the research process that need to find different ways of listening. Multi-disciplinary research requires funding agencies to re-align their thinking, particularly with regard to the structure and outcomes of multidisciplinary projects. Scientists who specialise in multi- or trans-disciplinary work often also find themselves in difficult positions at work where internal funding streams for research and job evaluation criteria are misaligned with the way in which they do their research, as well as the kinds of research projects they choose work on.

Natural and social scientists need to speak each other's language for successful co-operation between the different disciplines to take place. This issue of understanding one another, however, lies primarily at the practical level of the research. Some scientists argue that focusing on the need for a common language and understanding is not enough and that other, more complex, prerequisites, such as mutual respect for each other's work, also come into play. The interviews illustrate that developing a level of mutual respect can be quite difficult. One natural scientist illustrated this point by arguing that scientists generally only have respect for other disciplines if they believe they cannot do that particular work or research themselves. This implies that if a scientist thinks he/she can do someone else's work equally well, he/she does not have to respect them. This opinion ties in with the sentiments expressed by one of the social scientists who argued that ". . . *often natural scientists think they can do what we do because on the surface it looks easy – you talk to some people, you write down their words, have a focus group here and there and there you go! It is not as easy as it looks – sure you can go out and interview people but if you don't know what to look for or how to interpret what you are hearing then you are missing the whole point"*. Many of the scientists interviewed however argue that having respect for one another should not be grounds for clinging to one's domain and becoming territorial, rather there should be both co-operation (making an effort to understand each other through data and information sharing) and collaboration (suspending one's membership of a particular discipline for a certain amount of time and engaging wholeheartedly in a project).

Many of the scientists interviewed for this paper expressed the need for a different approach to research that will inevitably require the social and natural sciences to work together. Many argued that a divide between the two disciplines does exist, and at the same time they mentioned that occasionally it is fuelled by personalities and egos. Generally, however, the need was recognised for this gap to be closed and this was deemed essential for finding solutions to development-related and environmental problems. It is clear that many scientists believe that a new approach is needed, be it in the form of multi-disciplinary research, trans-disciplinary research, incremental research or fusion. This recognition points to the fact that *". . . a new kind of thinking and new kind of solution is required and that the problem needs to be rethought, because a limit of a particular kind of thinking has been reached. Scientists need to be acutely aware of this!"*

<u>Discussion: Resilience Thinking, the Knowledge Schism and Case Interviews:</u>

The case interviews shed light on the deep schism that exists between natural and social sciences. One camp is composed of those known as the behaviouralists, empiricists, positivists and/or realists; the other, of historicists, institutionalists, nominalists, normativists, interpretivists, phenomologists and/or relativists. In defence and in attack of one another, much ink has been shed over the dynamic tension between these two schools of thought (McGarr, 1994). However, not all natural scientists are positivists and not all social scientists follow the relativist paradigm (Mottier, 2005). The two ends of the spectrum (positivism and relativism) indeed represent two sets of philosophical commitments that are fundamentally divergent in how they view the nature of reality, sometimes also the goal of knowledge generation and the approach taken to generating that knowledge (Hudson and Ozanne, 1988 and Pimbert, 2004). Recognizing the existence of divergent and deeply ingrained philosophical commitments held within these scientific belief systems, it is easier to understand why reaching out, exchanging, and collaborating is challenging: it implies change and adaptation. However, it is important to note that based on the interviews and reviewed literature, there is a growing recognition, in general, among scientists that there is a need to integrate and work collaboratively on complex problems of today that demand transdisciplinary knowledge support for policy development.

Over time, as mapped earlier in resilience thinking, the social and natural sciences have branched out, and become increasingly specialized (Slocombe, 1993). With this specialization, knowledge development has had consequences such as the emergence of pure theory as experts operate on a level of considerable abstraction from the vicissitudes of everyday life, which is nuanced and multi-dimensional. This problem was earlier referred to as the efficiency paradox where too much specification produces gaps and fails to quantify things of value which is increasingly important in sustainable development policy and planning. A second consequence is a strengthening of traditionalism as each group's knowledge behaviour is reinforced and legitimised, for example, strengthening the inherent tendency of knowledge institutionalization towards inertia. This process results in knowledge depth, but it also limits the flexibility of human thoughts and actions. The case interviews elucidated this theoretical notion embedded within resilience thinking with the statement that "*…new kinds of thinking are required as the particular kind of thinking had reached its limit*" and is no longer suited to the large scale problems knowledge systems are obligated to address. Thus, we conclude that the more abstract the legitimations for the knowledge cluster, the less likely the knowledge cluster in the natural or social sciences is likely to be modified (Berger and Luckmann, 1966:135) in accordance with the pragmatic demands of the real-world problems of the day. The assertion that epistemological bridging mechanisms and innovative knowledge partnerships are necessary was supported theoretically according to resilience thinking, practically according to practitioners and academically in surveyed literature.

In sum, the characteristically isolated nature of the social and natural sciences is a problem for meaningful engagement with complex socio-ecological issues (Slocombe, 1993). Current challenges to policy are stemming from global climate change, how it affects economies and societies, as well as the way forward. Developing sustainably requires integrated knowledge, where parts of the system are seen holistically, which would be a new approach that further blends, but not fuses the specializations of the natural and social sciences. Successful change is already beginning to take place and there is evidence of support for a world view that promotes the integration of social and natural science contributions though thinking that acknowledges the world from a dynamic, systems-oriented approach (MacMynowski, 2007; Nelson, 2007; Burns et al., 2006; Bammer, 2005; Abel and Stepp, 2003; Bradshaw and Bekoff, 2001; Costanza, 2001; van der Leeuw and Aschan-Leygonie, 2000; Scoones, 1999; Wheatley, 1999). The gap between the social and natural sciences is in fact slowly closing as practitioners seek to adapt, change and innovate, but project design and the way that research is organised is in some cases a bigger hurdle than epistemological differences to generating integrated offerings (Quinlan and Scogings, 2004; Slocombe, 1993) as expressed by some frustrated interviewed scientists. However, by building on best practices of successful transdisciplinary research and projects one can apply "lessons learned" and contribute to knowledge growth in this new sphere of knowledge that combines strengths of the natural and social science methodologies and epistemologies.

Case Study: Lessons Learned

In October 2007, a group of twelve scientists (about one third of each natural scientists, social scientists and natural scientists with exposure to the theory and practice of social science) met for two days to discuss a topic of shared interest: making natural resource planning operationally successful. Paradigmatic differences between these individuals were quite evident. However, team spirit and an outline for a joint publication was the product of two days together. Most importantly, these achievements were underpinned by a deeper appreciation (though probably incomplete understanding) of each others' perspectives and epistemological traditions. The experience offered the scientists an opportunity for enhanced intellectual growth, by challenging and expanding their mental models, forming partnerships and building new networks through the process. So, in response in the natural scientist's articulation that "Conservation projects fail!" and their hypothesis that it is largely because of the lack of an approach that integrates the biophysical and social elements of the problem, the group agreed. This agreement indicates a view of the world consists of interrelated parts of which one type of science can address only some part or parts and that alone is an incomplete study. The group were able to design an outline for a joint publication that reflects the integration of their thoughts and a commitment to continue to work in this way. All indications are that this group will continue to operate as a community-of-practice (Snyder and Wenger, 2004) driven by the excitement and passion for a joint concern and joint learning, and less so by professional obligation.

This case study taught us that there are some essential ingredients for a successful and mutually advantageous interaction between practitioners of the natural and social sciences. By generating synergy between people and disciplines, the social science - natural science divide can be bridged. Lessons for this case study include the following. No agenda was set prior to meeting face-to-face. The agenda was created only once everyone was in the same physical space so that intentions and the meaning behind propositions could be checked and clarified. Secondly, everyone took a humble approach to interactions and no individual assumed epistemological superiority. Instead, participants listened and asked questions for clarification. Lastly, trust is a key and participants were encouraged to express their ideas honestly, even if they were in apparent conflict with other ideas present. Overcoming differences in divergent epistemological commitments is never going to be an easy task for any practitioner, but with time and practice, the task becomes easier. One must begin by talking to others outside one's discipline to initiate knowledge interaction and recognize that dialogue is both a tool and an outcome of cooperation.

Conclusion:

There is a need to respond to the challenges associated with global climate change and the affects that it has had and will have on communities and livelihoods. There is also a need to develop policy on sustainable development, and it must necessarily be underscored by transdisciplinary research to reflect the multifaceted nature of sustainability issues. The key to sustainability lies in enhancing system resilience, whether it is social, ecological or knowledge all of which are interrelated. The key is not to optimize the performance of isolated parts of the system, but to combine, link and integrate the parts. It is not the quantity of knowledge on the subject; it is the quality of it that is important.

Resilience thinking is part philosophy and part pragmatism. By mapping natural and social science knowledge systems within the complex adaptive system cycle, we were able to ascertain that the present time is ripe for adaptation and knowledge growth. Resilience thinking highlighted the risks associated with high levels of specialization within knowledge systems and the case interviews supported this position with a view that high levels of inflexible, abstract knowledge are not practical or needed to address sustainability challenges. However, high levels of knowledge specialization can be positive, but not if they exist in isolation from other spheres of knowledge as they presently tend to. Knowledge needs to be seen holistically as ecological systems are viewed, as part of the environment around them.

Interviews with science practitioners affirmed a broad recognition that integration is needed, but illuminated some of challenges in accomplishing successful knowledge partnerships. Sharing “best practices” on successful scientific bridging interactions is a crucial step to finding ways of overcoming problems with language, ingrained belief systems and a lack of mutual understanding and respect for other scientists. A case study on a researcher’s reflections demonstrated that with will and determination as well as an open mind, old ideas, and dogma can be transcended. Within existing knowledge systems, there is need, capacity and space right now for change; the time is now. Change, as it continues to evolve, will take the form of institutional learning within the social and natural science disciplines and in pragmatic terms where practitioners cross the knowledge divide and engage with each other in an open, non-judgemental and respectful intellectual arena. Change is vital. Global climate change is serving as an impetus to break down some deeply ingrained knowledge traditions and reconfigure epistemological relationships to meet socio-ecological challenges confronting the global community.

References:

ABEL, T. and STEPP, J.R. 2003. A new ecosystems ecology for anthropology. *Conservation Ecology* 7(3), 12. [Online]: http://www.consecol.org/vol7/iss3/art12

ANDERIES, J.M., JANSSEN, M.A. and OSTROM, E. 2004. A framework to analyze the robustness of social-ecological systems from an institutional perspective. *Ecology and Society* 9(1), 18 [Online] URL: http://www.ecologyandsociety.org/vol9/iss1/art18

BAMMER, G. 2005. Integration and implementation science: building a new specialization. *Ecology and Society* 10(2), 6 [Online]: http://www.ecologyandsociety.org/vol10/iss2/art6/

BRADSHAW, G.A. and BEKOFF, M. 2001. Ecology and social responsibility: the re-embodiment of science. *Trends in Ecology and Evolution* 16(8), 460-465.

BURNS, M., AUDOUIN, M. and WEAVER, A. 2006. Advancing Sustainability Science in South Africa. *South African Journal of Science* 102 (September/October 2006), 379-384.

COSTANZA, R. 2001. A vision of the future of science: reintegrating of the study of humans and the rest of nature. [Online]: www.uvm.edu/giee/discuss/Future-Costanza.html

BERGER, P.L. and LUCKMANN, T. 1966. The social construction of reality: a treatise in the sociology of knowledge. Harmondsworth: Penguin Books

BISWAS, A. K. Integrated Water Resource Management: a reassessment. *Water International*, 29(2), 248-256, June 2004.

BURNS, M. 2007. Resilience theory as an approach to sustainability analysis. *International Journal of Environmental, Cultural, Economic and Social Sustainability*, 3.

CHARTRAND, H.H. 2002. The great social science schism: tales from the methodological woods. The competitiveness of nations in a global knowledge based economy. May 2002.[Online] www.members.shaw.ca/compilerpress1/827%20Final.htm.

CARPENTER, S., WALKER, B., ANDERIES, J.M. and ABEL, N. 2001. From metaphor to measurement: resilience of what to what? *Ecosystems,* 4, 765-781.

FOLKE, C. 2006. Resilience: The emergence of a perspective for social-ecological systems analyses. *Global Environmental Change*, 16, 253-267.

GUNDERSON, L.H. and HOLLING, C.S. (Eds.) 2002. Panarchy: understanding transformations in human and natural systems. Washington D.C.: Island Press.

GIAMPIETRO, M. 2004. Multi-scale integrated assessment of agro-ecosystems. London: CRC Press.

HOLLING, C.S. and MEFFE, G.K. 1996. Command and control and the pathology of natural resource management. *Conservation Biology*, 10, 328-337.

HOLLING, C.S. 2001. Understanding the complexity of economic, ecological and social systems. *Ecosystems*, 4, 390-405.

HUDSON, L.A. and OZANNE, J.L. 1988. Alternative ways of seeking knowledge in consumer research. *The Journal of Consumer Research* 14(4), 508-521.

MACMYNOWSKI, D.P. 2007. Pausing at the brink of interdisciplinarity: power and knowledge at the meeting of social and biophysical science. *Ecology and Society* 12(1), 20. [Online]: http://www.ecologyandsociety.org.vol12/iss1/art20

MCGARR, P. 1994. Engels and natural science. *International Socialism Journal*, 65, Winter 1994. [Online] http://pubs.socialistreviewindex.org.uk/isj65/mcgarr.htm

MAKUNDA, N. 1999. From natural to social science- a bridge. *Journal of Genetics*, 78(3), December 1999. Book Review: WILSON, E.O. 1998. *Consilience: the unity of knowledge*. Knopf, New York

MILLENNIUM ECOSYSTEM ASSESSMENT. 2005. Available at: [Online] www.millenniumassessment.org.

MOBERG, F. and GALAZ, F. 2005. Going from conventional to adaptive freshwater management for human and ecosystem compatibility. Swedish Water House Policy Brief Nr. 3. Swedish International Water Institute. [Online]: www.siwi.org.

MOTTIER, V. 2005. The interpretive turn: history, memory and storage in qualitative research. Forum: Qualitative Sozialforschung/Forum: Qualitative Social Research 6(2), article 33. [Online]: http//www.qualitative-research.net/fqs-texte/2-05/05-2-33-e.htm.

NELSON, D. 2007. Expanding the climate change research agenda. *Anthroplogy News* 48(9), 12-13.

PIMBERT, M. 2004. Institutionalizing participation and people-centred processes in natural resource management. Research and Publication highlights. Report published by the International Institute for Environment and Development. London. ISBN: 1 84369 629 0.

REDMAN, C.L. and KINZIG, A.P. 2003. Resilience of past landscapes: resilience theory, society and the *longue durée*, *Conservation Ecology*, 7(1), 14.

SCHEIN, E.H. 1995. Kurt Levin's Change Theory in the field and in the classroom: notes toward a model of managed learning.
[Online]: http://www.solonline.org/static/research/workingpapers/10006.html

SCHUMPETER, J. 1950. *Capitalism, socialism and democracy*. New York: Harper and Row.

SCOONES, I. 1999. New ecology and the social sciences: what prospects for a fruitful engagement? *Annu. Rev. Anthropol.* 28: 479-507.

SLOCOMBE, D.S. 1993. Environmental planning, ecosystem science and ecosystems approaches for integrating environment and development. *Environmental Management* 17 (3), 289-303.

SNYDER, W.M. and WENGER, E. 2004. Our world as a learning system: a communities of practice approach. *In:* M.L. Conner and J.G. Clawson (eds.), *Creating a learning culture: strategy, technology and practice*, Cambridge, Cambridge University Press.

UNESO: People, diversity and ecology: biosphere resilience. [Online]: htttp://www.unesco.org/mab/BRs/resilience.shtml

VAN DER LEEUW, S.E. and ASCHAN-LEYGONIE, C. 2000. A long-term perspective in resilience in socio-ecological systems. Paper presented at the workshop on System Shocks - System Resilience, held in Abisko, Sweden, May 22-26, 2000.

WALKER, B. and SALT, D. 2006. *Resilience thinking: sustaining ecosystems and people in a changing world.* Washington D.C.: Island Press

WHEATLEY, M. 1999. *Leadership and the new science: discovering order in a chaotic world.* First edition. Berrett-Koehler Publishers.