Community Conservation Research Network (CCRN)

Guidelines for Analysis of Social-Ecological Systems

Prepared by the CCRN Working Group on Social-Ecological Systems and Community Resilience

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Contents

1. The CCRN's Research Approach

One of the key premises of the Community Conservation Research Network (CCRN) is that to effectively respond to environmental challenges, people need to find (or re-discover) suitable ways to govern ourselves, to make decisions that meet our needs for both conservation and livelihoods. A fundamental question we raise is "How can local communities, across Canada and around the world, meet these challenges of sustainable development, in maintaining healthy economies and sustainable livelihoods as well as a healthy environment?" The CCRN's response is to address this fundamental question by examining the scope for improved environmental stewardship and sustainable resource management through local-level and community-based initiatives, and through multi-level environmental governance.

In our CCRN research, we are addressing the reality that, while there are many known examples of local-level conservation, there remain significant gaps in knowledge, and an accompanying need for new policy insights. There are also challenges in balancing ecosystem health with short-term and long-term socioeconomic and livelihood goals. The CCRN's work is leading to a better understanding of and support for governance arrangements and the strengthening and better integration of local initiatives into networks of conservation action. All this is crucial if governance and policy measures are to be designed and implemented so as to address environmental issues most effectively now and in the future.

The big tasks that the CCRN is undertaking cannot be accomplished from a narrow perspective, so the CCRN team has adopted a "big-picture" research approach that includes three inter-related aspects:

1. Social-ecological systems
2. Governance
3. Community-based resource management and conservation.

In this guidebook, we focus on the social-ecological systems perspective, which CCRN participants have agreed will be the network's main conceptual framework. This guidebook examines what a "social-ecological systems" (SES) lens means, and how we can use it in the CCRN and beyond. In addressing this, we also look below at links to the other two key components of our research approach – governance, and community-based resource management and conservation. [Note that definitions of many of the terms used in this guidebook are provided in Appendix 1, and key concepts are described in Appendix 2.]

2. The Idea of and Rationale for a Social-Ecological Systems Lens

The basic idea of SES is to be explicit in linking together the 'human system' (e.g. communities, society, economy) and the 'natural system' (e.g. ecosystems) in a two-way feedback relationship. This integration of humans in nature is important because in any conservation effort, there are interactions and 'feedback' between ecological (biophysical) and social (human) subsystems. This includes essential links related to people's knowledge (e.g., local or traditional knowledge), and management institutions, as well as 'rules' and 'norms' that mediate how humans interact with the environment. For these reasons, an SES

lens is crucial. Such a perspective also builds on widely-accepted thinking of the Millennium Ecosystem Assessment (MEA), which was a major effort to look at the current state of ecosystems globally, and how humans affect them. The MEA focused on 'drivers' of change, human 'wellbeing' and 'ecological services', and recognized that SES are uncertain and 'complex' in that feedbacks occur in ways that are not necessarily predictable. This uncertainty, complexity and unpredictability are major factors to deal with in assessing SES.

An SES lens is also crucial for very practical reasons. Integrated studies of coupled human and natural systems reveal new and complex patterns and processes that were simply not evident when studied by social or natural scientists separately. Liu et al. (2007) studied six well documented cases of social-ecological systems from around the world. They found that the cases showed complex patterns and processes: non-linear dynamics with 'surprises', feedback loops, time lags, and other complex behaviour. Many of these patterns and processes became apparent only when the full social-ecological system was taken as the unit of analysis.

The social-ecological systems lens draws on many concepts and approaches but in the form we are using, it always includes three key factors – multiple scales, multiple levels, and resilience. Each of these is described below.

1. Multiple scales. "Scale" refers most often to time and to space, specifically whether an event (like a fishery opening) occurs over a short or long time (temporal) scale, or whether an activity (like fishing) takes place over a small or a large space (spatial) scale. For example, a herring roe fishery in BC may happen over just a few minutes, in a very local area (thus, a short time scale and a small spatial scale) whereas a tuna fishery may involve boats roaming over much of an ocean for a matter of months (thus a longer time scale and a much larger spatial scale). Another common use of the idea of scale, keeping to the fishery focus of this paragraph, is that of large-scale and small-scale fisheries – this is an example of an 'analytical dimension' in that the concept of a 'small-scale fishery' is a way to help us focus on certain aspects of those fisheries versus those of a larger scale.

Given our focus on the interplay of local and larger-scale environmental initiatives, it is crucial to address variations across scales. How conservation challenges are perceived and addressed in a local setting (e.g., Annapolis Basin, Nova Scotia) may differ greatly from that of a broader scale (Bay of Fundy, eastern Canada or the country as a whole). Governance (see below) is similarly challenged by multiple scales, and the need for cross-scale approaches. Environment Canada, for example, notes the need for suitable regional governance responsive to both local initiatives and national policy initiatives. Monitoring outcomes also requires attention to scale: cross-scale 'systems thinking' might allow conservation outcomes to be tracked across scales.

An illustration of the implications of considering different scales when analyzing resource management comes from the south coast of Rio de Janeiro State, in Brazil. Studies of small-scale fisheries management took place at three different scales in that region: (i) the geographical scale related to resource use (local/community level, the Paraty municipality area, and the Ilha Grande Bay area – which encompasses other municipalities); (ii) the temporal scale regarding the development of new initiatives related to SSF management;

and (iii) the socio-political scale related to these initiatives involving different stakeholders (community-based organizations; regional forum of traditional people; municipal, state and federal government; universities, NGOs and private sector (from community-based enterprises to national level enterprises).

2. Multiple levels. Parallel to the idea of scale is that of 'level' – basically a specific point along a scale (or a 'unit of analysis' within a scale). For example, if we are interested in a spatial scale, a community marine protected area (MPA) would be at a small spatial scale, compared with the scale of a large high-seas MPA. The idea of 'level' is most often used, however, in referring to levels of governance. For example, it is often noted that "high-level" governmental policy should enable innovation and conservation success at a community scale, while "low-level" mobilization of a community, and horizontal networks, can drive change at higher levels.

A multi-level approach is important in allowing us to examine different levels at which conservation interventions can be made. We will seek to understand the interplay of drivers linking high-level enabling policies and approaches, with local-level environmental initiatives, by examining cross-scale linkages and environmental governance in the context of social-ecological systems.

To continue the example above from Brazil, conflicting interests and power asymmetry among stakeholders at different levels of the social-political scale, as well as discontinuity of SSF management initiatives at different levels of the geographic scale, have both created a complex and fragmented management system, with strong consequences for the small-scale fisheries system.

3. Resilience. The idea of resilience is to be able to maintain the overall function and structure of a system of humans and nature, despite unexpected shocks to that system. The term 'social-ecological resilience' specifically focuses thinking on how resilience, or its absence, affects all aspects of the SES. In CCRN research, we need to look at how local environmental stewardship initiatives and livelihood activities interact with higher-level policy, and how all of these affect social-ecological resilience.

The CCRN research team includes strong expertise to examine this both locally (e.g., how communities perceive resilience, how this varies internally, and governance implications) and at a larger scale (e.g., how government policy impacts on local and regional environmental resilience and social cohesion). A key aspect is that of environmental and community shocks, such as those arising with global climate change and economic change), and the interrelationships of these with community conservation initiatives, across multiple scales.

While this section has emphasized the basic idea of SES and the three key SES concepts of scale, level and resilience, there are other important concepts that often arise in SES research. Some of these – transformation, thresholds, emergent properties, drivers, feedback, collective action, worldviews, power and agency – are described in Appendix 2.

3. SES and Governance

Governance can be seen as a system of rules, institutions, organizations and networks set up "to steer societies towards preventing, mitigating, and adapting to global and local environmental change" (Biermann et al. 2009). An SES lens contributes to thinking about governance by highlighting the importance of conservation-focused institutions and governance arrangements that (1) match complex social-ecological systems, (2) adapt as these systems change over time, and (3) help steer these systems towards sustainability. Some of the key ingredients for success here are (i) the presence of 'multi-level institutions', (ii) partnerships among state and non-state actors, (iii) appreciation of diverse perspectives and knowledge, and (iv) shared learning and social processes that provide opportunities for adaptability.

Several critical insights for conservation can be drawn from the emerging literature linking social-ecological systems and governance:

- Social-ecological change and uncertainty, and the implications for community conservation in a tightly-connected world, are not well understood.
- Community conservation, stewardship and related governance arrangements cannot be 'fixed' to an ideal spatial or temporal level – a multi-level perspective is essential.
- Identification of motivations, meanings and governance attributes for effective community conservation in complex social-ecological systems is only now emerging.

In applying an SES lens to issues of governance, it is crucial to better understand how various governance arrangements can promote conservation that sustains human well-being and the ecosystem services upon which we depend. While governance arrangements will vary from place to place, our interest is to determine the "ingredients" of these arrangements that seem to work to promote conservation objectives and are broadly acceptable to local communities in achieving a fundamental balance between food and livelihood needs, on the one hand, and the need to ensure the ecosystem and its resources reproduce and continue to provide goods and services. An SES lens ensures a broad enough perspective on the human-nature system to be able to address these goals. For example, in asking how to recognise effective and equitable local conservation initiatives and practices, whether operating inside or outside the formal state governance system, we need to evaluate effectiveness from all angles of the SES. We also ask how these initiatives become integrated into a higher-level network of conservation efforts, a matter of multi-level governance. Further, we ask to what extent are governance processes emerging in complex conservation situations adapted to change and uncertainty, which will arise across the particular SES.

4. SES & Community-based Conservation / Management

The CCRN is drawing on research that shows how local institutions can develop successful environmental stewardship and management of natural resources. While this has been shown clearly by Nobel Prize winner Elinor Ostrom and many others, there is a lack of knowledge about how this works when there is involvement of multiple economic sectors. An important example of such gaps arises along coastlines, where the land-sea interface is impacted by increases in human settlement and in economic activity, leading to environmental impacts of fishing, shipping, mining, urbanization, etc. These environmental

impacts arise across multiple scales, with the natural flow of the seas connecting local-level systems to processes operating at larger national and international scales. Thus the conservation challenges faced by individual coastal communities are inter-connected with those found at larger scales, a reality that has major implications for governance.

Accordingly, the CCRN is exploring how community-based initiatives interact with policy and instruments that are implemented, typically by governments, at other levels and scales. Indeed, local initiatives need to be accompanied by cross-scale linkages and scaling-up mechanisms so as to fit into broader frameworks. A multi-scale approach also reflects a shift in thinking on good governance, as 'top-down' approaches are replaced by participatory processes involving local communities, often as partners with civil society organizations, higher levels of government or industry. This is evident, for example, in large-scale systems of parks and protected areas that aim to meet global and national conservation targets, with success in practice depending greatly on the suitability and acceptance of community-scale institutions and incentives. While this new governance thinking has become widespread, its real-world application is not uniform. Despite many examples of local-level conservation, fundamental gaps remain between theory and reality, between ideas and practice. These gaps hold us back from effectively meeting joint socio-economic and environmental challenges.

5. SES and the CCRN's Main Themes

CCRN research will use the unifying lens of social-ecological systems to focus on the four key themes of meaning, motivation, governance and outcomes. As governance has been discussed above, here we focus on the other three themes.

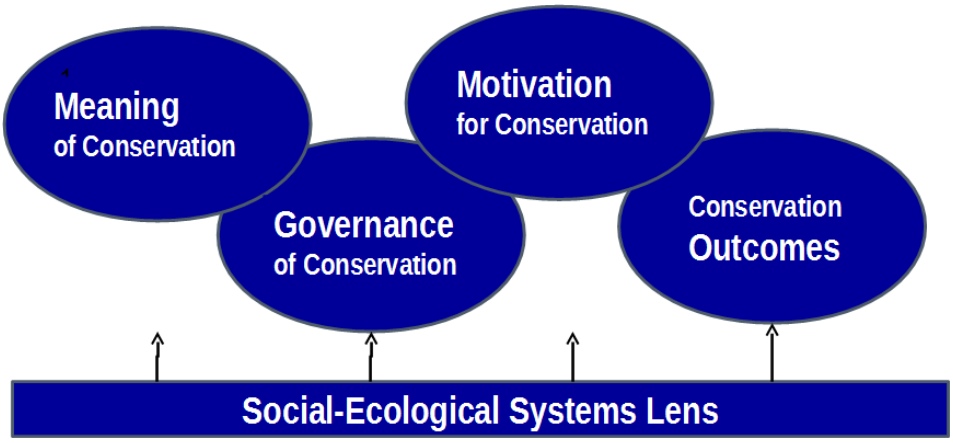

FIGURE 1: The four main themes of CCRN

Meaning. We take a view of conservation and stewardship as actions (including community initiatives, governance arrangements and policy measures) to ensure long-term sustainability of resources and associated livelihoods. But what is meant by 'conservation' and 'stewardship' in local communities and among governments and NGOs? These questions may have great impacts from a policy perspective if success of environmental initiatives can be improved by better fitting an understanding of the terms with local

realities and needs. Does the meaning attached to ideas of 'conservation' and 'stewardship' vary between different social-ecological systems? For example, in considering the natural resources and ecosystems on which a typical place-based rural community depends for local livelihoods – such as fisheries, forests, wildlife, or land for farming – do the meanings of 'conservation' and 'stewardship' vary between these different resource systems? How do environmental aspirations interact with ideas of economy and livelihoods, and how does this vary across scales of the SES?

Motivation. What are the motivations (or lack thereof) for environmental conservation and stewardship? Who is or is not motivated to be involved in stewardship, both locally and within high-level governments? How closely linked are conservation motivations to concerns about sustainability of livelihoods and economies? Underlying these questions are important issues of the strength of linkages between humans and the natural world, i.e. of the structure and interactions within the SES. For example, both (1) recognition of the need for healthy resource systems to ensure food and livelihood security, and (2) interactions between economic goals, drivers and constraints and conservation interests, are intrinsic within the SES.

Outcomes. What constitutes 'success' in environmental conservation and stewardship? Outcomes of conservation initiatives, whether community-led or government-driven, will be multi-dimensional in nature, since we will need to consider environmental outcomes, socioeconomic and livelihood outcomes, socio-cultural and equity factors, as well as governance processes. We need to monitor the impacts of human use and conservation actions across the entire SES, focusing on outcomes from components of the system that are viewed as of most relevance or importance. Systematic indicator frameworks can be key tools to ensure that we cover the breadth of the SES in monitoring outcomes – for example, understanding the various values underlying environmental conservation, and addressing socio-economic and livelihood interactions.

6. Doing SES Analysis

To this point in these guidelines, we have explored the nature of a social-ecological system lens, the rationale for its use within the overall research framework and goals of the Community Conservation Research Network, and how the SES lens relates to the major CCRN focus on community-based conservation and resource management, and to the specific themes of governance, meaning, motivation and outcomes.

In this section, we seek to describe how to go about 'doing' a social-ecological systems analysis, whether as original research or as a means to express existing knowledge in an SES context. This is done below by describing two examples of applying integrated SES thinking, one briefly (for Tokyo Bay, Japan) and the other in detail (for Port Mouton Bay, Nova Scotia, Canada). First, it is important to realize that there is no unique way to 'do' an SES analysis, but rather there are some common ingredients. These include (1) a fundamental focus on the integrated nature of social-ecological systems, with natural, human and governance sub-systems, as well as (2) attention to the multiple scales, multiple levels and resilience attributes of the system, as noted earlier.

In achieving the first of these common ingredients, there are many ways possible to describe the integrated nature of an SES. For example, one can think of three interacting sub-systems of the overall SES – the 'natural' system, the 'human' (or 'social') system and the 'management' (or 'governance') system. This is referred to as the Resource System Approach (see Appendix 3, and Charles 2001). Alternatively, one can consolidate these three components into two sub-systems. One way to do this, in keeping with the basic SES idea, involves 'ecological' and 'social' systems, with governance included in the latter. Another involves the 'resource system' and the 'governance system' (Ostrom 2009).

Figure 2 describes the model of an SES framework that the Working Group has developed for use in CCRN case studies. This builds on the Ostrom (2009) approach with a 'resource system' (that provides 'ecosystem services') and a 'governance system' (that incorporates the 'human' component of the SES, referred to here as 'users/communities'). Figure 2 also indicates the interactions back and forth between these 'sub-systems' of the SES. Importantly, and in keeping with the CCRN's research themes, Figure 2 also shows meanings, motivations and outcomes as key aspects connecting the resource system and the governance system, as well as connecting ecosystem services, resource users and communities. This framework is used in the two examples presented below.

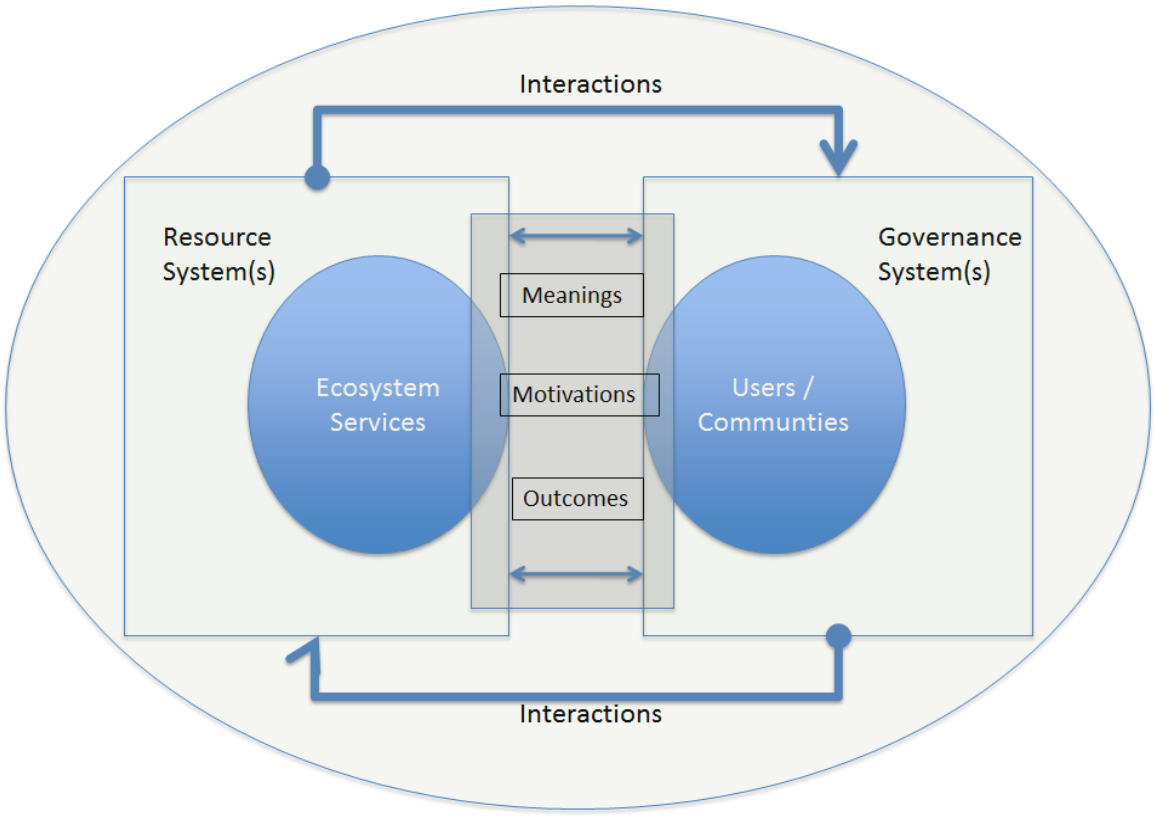

FIGURE 2: Social-ecological system for community conservation

Example: Tokyo Bay, Japan – "Re-planting of Seagrass Beds"

by Mitsutaku Makino, Fisheries Research Agency, Japan

Since the 17th century, Tokyo Bay has been famous as a production area of high quality fish for sushi, such as conger eel, mantis shrimp, sea bass, smelt-whiting, dotted gizzard shad, oval squid, etc. According to maps of the fishing grounds from the late nineteenth century, the majority of the coastal areas were tidal lands and shallow bottoms covered by seagrasses.

Since then, Tokyo Bay has been developed and reclaimed. Especially since the 1960s, the national government promoted development of heavy industry in Tokyo Bay. Indeed, this was the main driver of Japanese economic growth in the 1960s and 1970s. Now, Tokyo Bay is one of the most urbanized bays in the world. In Yokohama City, which faces the west coast of Tokyo Bay and is Japan's second largest city, only 0.5 km of natural coastline is left, out of 140 km of total coastline. As a result, seagrass beds, whose existence is crucial for the egg and juvenile stages of fish and shellfish, have almost entirely disappeared around urban areas such as Yokohama City.

In 1981, a group of scuba divers started an activity to clean the ocean bottom, and local researchers started experimental re-planting of sea grasses. Then, local fishers established a No-Take zone in this area. Now, local residents, schools, environmental NGOs, private companies, etc. have all joined the re-planting activities.

Interaction with high-level policy: A formal alliance among the above groups was established, and since 2003, government bodies (City, Fisheries Agency, Cabinet office, etc.) are financially supporting this alliance.

Meaning of "Conservation": The pictures below are famous woodblock prints (called *Ukiyoe* in Japanese) of Tokyo Bay, printed in the early 19th century. Note that people are living along the coast line, harvesting sea food, and enjoying boat cruises. This longstanding use of the coast indicates that, unless the objective of MPAs or ecosystem conservation is to return to the original wilderness of hundreds of years ago, local people's lives on the coast are not something to be eliminated from the ecosystem, but an indispensable component of that ecosystem.

Outcomes: These conservation activities have successfully expanded the areas covered by seagrasses. As a measure of success, spawning of oval squid was observed in 2004 for the first time in 30 years.

Example: Port Mouton Bay, Nova Scotia, Canada

"A Case of Community Conservation and Livelihood Action"

by Laura Loucks, Royal Roads University, Canada

This case study is available on the Community Conservation research Network website:

http://www.communityconservation.net/resources/port-mouton-bay/

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Appendix 1: Definitions

Note that there are often multiple definitions of these terms. For resilience related terms and key concepts: http://www.resalliance.org/index.php/key_concepts

Adaptive Capacity: The ability of social actors or systems to cope with change or disturbance and/or learn through uncertainty.

Adaptive co-management: A flexible system of collaborative resource management, tailored to specific places and situations, supported by, and working in conjunction with, various organizations at different levels. Merges the principles and practices of co-management and adaptive management (Armitage et al. 2009).

Adaptive management: Systematic learning-by-doing.

Agency: the ability of individuals or groups to undertake actions despite constraints imposed by larger social or material structures (Giddens 1984; Bordieu 1977).

Bridging organizations: Serving as catalysts and facilitators, these organizations provide an arena for knowledge co-production, trust-building, sense-making, learning, vertical and horizontal collaboration, and conflict resolution (Berkes 2009).

Clumsy solutions: Exploratory solutions that include inputs from a range of stakeholders along the fish chain and require information-sharing, knowledge synthesis and trust-building, where approximations are needed to move forward (Khan and Neis 2010).

Co-management: A resource management partnership in which local users and other stakeholders share power and responsibility with government agencies (Armitage et al. 2007).

Community conservation refers to practice of conservation initiated and developed by local people. However, in some cases, community conservation may be resulted from devolution of the government to the local people. Satria et.al (2004) identified types of *awiq-awiq* as model of community conservation based on source of initiation.

Community of Practice: A social group or learning network that develops around shared interests or activities.

Community resilience: The existence, development and engagement of community resources by community members to thrive in an environment characterized by change, uncertainty, unpredictability and surprise (Magis 2010).

Community vulnerability: refers to degree of to which a community is sensitive to and exposed to particular conditions and shocks, considering community adaptive capacity to deal with. If a community is too sensitive to natural hazards with low adaptive capacity, we call it as vulnerable.

Complex system: is comprised of a number of non-linear interactions among its interdependent parts. One cannot understand the system behavior by just considering each of the parts and combining them. Instead one must consider how the relationships between the parts affect the behavior of the whole. Feedback among its interdependent parts allows for self-organization of complex systems.

Co-production of knowledge: the collaborative process of bringing a plurality of knowledge sources and types together to address a defined problem, and build an integrated or systems-oriented understanding of that problem (Armitage et al. 2011).

Culture : Culture is the customs, arts, social institutions, etc. of a particular sector, society or nation (CBD Ecosystem Approach). Different sector, society or nation views ecosystems in terms of their own cultural and economic needs. Therefore, culture considerably influences how the ecosystems and their services are valued by specific sector, society or nation.

Driver: A natural or human induced factor that causes a change in a system.

Ecosystem services: The benefits to human society from ecosystems.

Emergence: A characteristic of a complex adaptive system that cannot be predicted or understood simply by examining the components of the system.

Feedback Loops: The process by which system outputs are returned to the system as an input, either to oppose the initial input (negative feedback), or to enhance it (positive feedback).

Governance: The public and private interactions undertaken to address challenges and to create opportunities within society. Governance thus includes the development and application of the principles, rules, norms and enabling institutions that guide public and private interactions (Armitage et al. 2009).

Incentives (re: resource conservation and stewardship): Building of institutional systems that provide incentives to individual fishers and enterprises that lead to behaviour consistent with conservation (Hilborn et al. 2005).

Institutions: The formal (rules, laws, constitutions, organizational entities) and informal (norms of behaviour, conventions, codes of conduct) practices that structure human interaction (Armitage et al. 2009).

Institutional interplay and linkages: Such relationships among organizations and institutions , both vertically across levels and horizontally within the same level, have been identified as critical factors in building resilient social-ecological systems (Gunderson et al. 2006).

Integrative science: Methods and processes to support suitable institutional responses, a broader planning perspective, and development of suitable resilience-building strategies (Miller et al. 2010).

Level: see scale.

Memory: Accumulated experience and history of the system (both social and ecological) which provide the basis for self-organization (Armitage et al. 2009).

Multi-level governance: Governance involving links that may be horizontal (across geographic space) or vertical (across levels of organization), with the recognition that there often is no single spatial or temporal level of analysis for governing social-ecological systems (Brondizio et al. 2009).

Networks: The interconnections among people and organizations within a social-ecological system. Networks may structure themselves around resource use, administrative responsibility and/or other functions and may be connected to other networks (Armitage et al. 2009).

Polycentric systems: Institutions which are nested, quasi-autonomous decision-making units operating at multiple scales, balancing between c0entralized and decentralized control (Folke et al. 2005).

Regime shift: A regime shift (or "flip") is said to occur when a critical threshold has been crossed and a system shifts into an alternate configuration controlled by different feedbacks.

Resilience: the capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity and feedbacks (Walker et al. 2004).

Scale: The spatial, temporal, quantitative, or analytical dimensions used to measure and study any phenomenon; levels are the units of analysis that are located at different positions on a scale (Cash et al. 2006).

Self-organization: In adaptive co-management, self-organization involves the emergence of formal and informal networks, working in a collaborative and creative process, often drawing on a range of knowledge sources and ideas (Armitage et al. 2009).

Social capital: The social norms, networks of reciprocity and exchange, and relationships of trust that enable people to act collectively (Armitage et al. 2009).

Social-ecological systems: integrated complex systems that include social (human) and ecological (biophysical) subsystems in a two-way feedback relationship (Berkes 2011).

Social learning: The collaborative or mutual development and sharing of knowledge by multiple stakeholders through learning-by-doing. Learning may involve the identification of strategies or actions (e.g., harvesting techniques) to resolve specific problems and improve outcomes (e.g., improved incomes, higher yields). Alternatively, learning may involve fundamental changes in underlying values or worldviews – sometimes referred to as transformative learning.

Stewardship (ecosystem stewardship): A strategy to respond to and shape social-ecological systems under conditions of uncertainty and change, to sustain the supply and opportunities for use of ecosystem services to support human well-being (Chapin et al. 2010).

Surprise: unexpected findings about the natural environment or social-ecological systems that do not conform to formal hypotheses or working conceptions of what is deemed likely (Lindemayer et al. 2010).

Threshold: An abrupt breakpoint between alternate states of a system, where a small change in the controlling variable produces a large change in the characteristic structure, function and feedbacks of the system (Arctic Council 2013).

Tipping point: A kind of threshold characterized by bifurcation in a system (Arctic Council 2013).

Wicked problems: Problems that have no definitive formulation, no stopping rule, and no test for a solution.

Appendix 2: Key Concepts Underlying an SES Perspective

The following concepts arise in much of the published research involving SES. Drawing on these concepts for CCRN research may be useful.

Transformation involves a fundamental or systemic shift in a social-ecological system when existing social, economic, political and ecological conditions are untenable. A good example comes from the transformation of the Kristianstad wetland landscape in Sweden experiencing significant degradation (Olsson et al. 2004). The case is valuable because it highlights the social processes leading to the transformation toward ecosystem management. The transformation involved three phases: 1) preparing the system for change, 2) seizing a window of opportunity, and 3) building social-ecological resilience of the new desired state. This local policy entrepreneur initiated trust-building dialogue, mobilized social networks with actors across scales, and started processes for coordinating people, information flows and ongoing activities, and for compiling and generating knowledge, understanding, and management practices of ecosystem dynamics. Understanding, collaborative learning, and creating public awareness were part of the process (Olsson et al. 2004).

Thresholds are the critical boundary (e.g., spatial, temporal) or break point between two alternate system configurations. When crossed, thresholds can involve (but not always) sudden and dramatic changes. There are many classic examples of thresholds in social-ecological systems. A well-studied example is the shift from intact coral-dominated reef to an algae-dominated reef. In this case, fish herbivory, sediments, nutrient run-off and climate (warming, acidification) have coalesced to cross thresholds. Where thresholds have been crossed in coral reef systems (as in much of the Caribbean), there are significant implications for fisheries, tourism, hazard protection, etc. Thresholds may be determined through ecological models, but thresholds also have a social component (i.e., thresholds may be socially defined and the implications of threshold changes felt differently by different groups).

Emergent Properties - Resource management decision-making has often focused on setting objectives that address a specific problem (Cundill et al. 2012). However, Checkland (2000) argues that in complex social ecological systems, the nature of the problem is difficult to understand and the associated solutions are equally challenging to clarify. In most cases, the goals and objectives proposed result in a series of side effects or unintended consequences. In contrast to conventional goal setting, the identification of purposeful action is an important emergent property that arises from sharing multiple perspectives (worldviews) on the nature of the system and the situation (Wals 2007). Research on Canadian prairie farmer learning strategies for adapting to climate change highlights the importance of multiple sources of information and social learning feedback processes to facilitate the emergent properties of new behavioural norms for sustainable farming practices (Tarnoczi 2010).

Drivers. A broad range of factors lead to changes in social-ecological systems. MA defines drivers as any natural or human-induced factor that directly or indirectly causes a change in a social-ecological system. A direct driver (for example, changes in local resource use) is one that can be identified and measured. Indirect drivers (for example, demographic change)

operate more diffusely, often by altering one or more direct drivers, and their influence is established by understanding their effects on direct drivers. MA emphasizes that there are almost always multiple factors of change, and their effects are multiplicative rather than additive (Millennium Ecosystem Assessment 2003).

Feedback. Social-ecological systems (and other complex systems) show surprises because of self-reinforcing or self-moderating processes (vicious or virtuous cycles). If a loop in the system sustains the direction of change, it is called a positive (reinforcing) feedback. If it reverses the direction of change, it is called a negative (balancing or stabilizing) feedback. In a study of how forest degradation was replaced by net forest increase, Sendzimir and colleagues (2011) found that tree density started to increase in the 1980s when the influence of government forestry officers declined and farmers started to experiment with locally devised techniques, reversing the direction of change. Increased tree density reinforced the sense of tree ownership and steward ship, resulting in further forest increase.

Collective Action - The theory of collective action suggests that people will only be motivated to cooperate under conditions in which the benefits from cooperating exceed the individual costs and the problem of free-riding is resolved (Olson, 1965). Research on agricultural fertilization practices in Sweden revealed that once farmers were aware their actions were contributing to water eutrophication in the adjacent catchment area, they did not view the problem as being theirs alone to resolve, nor did they perceive that they would benefit individually from changing their practices. They also perceived that even if farmers did agree to cooperate to engage in new practices, not every farmer was equally trustworthy in their behaviour. Hence, “the 200 farmers saw themselves as stuck with a disproportionate share of the burden for providing clean water quality, while a large share of the benefits would go to the thousands of ‘non-paying others’ in the catchment area” (Lundquivist 2001:12). Ostrom (1990:18) argues that when “individuals repeatedly communicate and interact with one another in a localised physical setting ... it is possible that they learn whom to trust ... and how to organize themselves to gain benefits and avoid harm”. However, in the same way a barrier to collective action can arise when social capital is eroded and people develop a sense that not everyone can be trusted to behave consistently for collective benefit.

Worldviews - Every culture has its own way of thinking of the world and the cosmos, as well as of the origin and functioning of the universe. Most often, each worldview entails a different complex of knowledge, practice and beliefs, which is mediated by social institutions and management systems (Berkes 2013). In working with SES, understanding worldviews -in which local and traditional management systems are embedded, are of paramount importance. In this respect, in order to understand local stewardships in place, researchers need to study the worldview as a key concept held by any community or group of users (see Reichel-Dolmatoff 1976). Understanding worldviews becomes especially relevant in our CCRN because it works on meanings of conservation, motivations for conservation, and conservation outcomes.

Power and Agency - Understanding power and agency becomes relevant in our CCRN because it works on how conservation is shaped and who has more access to get benefit from it. Conservation is not about natural resources only, but rather about relationship

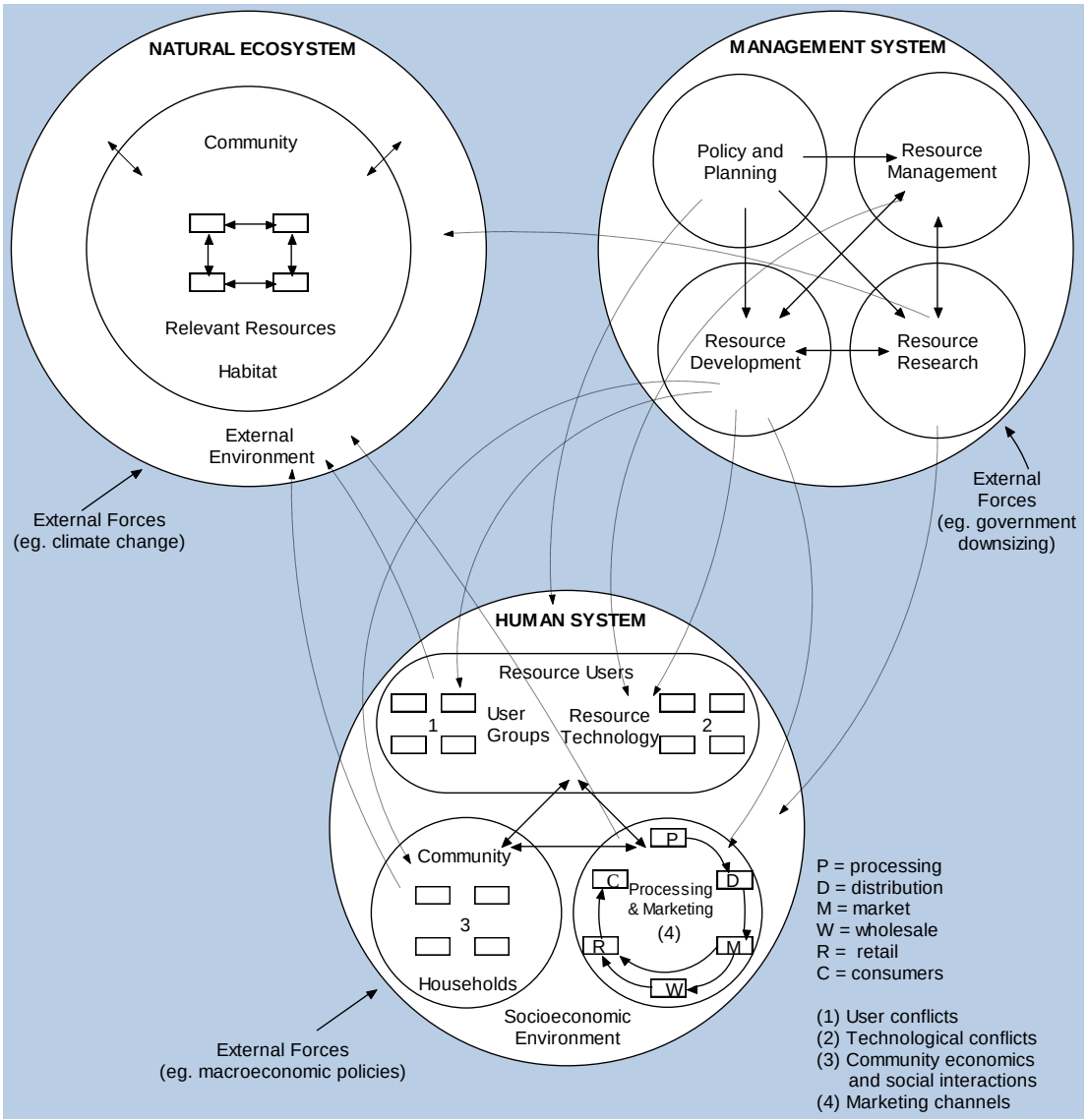
between ecosytem and socio-political-economical system, wherein power is an important factor. Politics and environment are interconnected (Bryant and Bailey 2000), and the rise of political ecology tries to analyze such connection. It needs to focus on the interests, characteristics and actions of different types of actors. Conservation is an arena wherein interests invested with power are contested. Accordingly, Zimmerer and Basett (2003) argue that spaces of conservation become arenas of conflict that result in distinctive patterns of resources management. This conflict issue in marine conservation is also shown by Satria et.al (2006). Moreover, conservation is associated with the control of resources that has been wrested from the local people through the implementation of state and global interests to preserve the environment at the expense of local livelihoods, production and socio-political organisation (Robbins 2004). The outcome of conservation depends on the situation of power relation among actors.

Appendix 3: Frameworks for analysis

The following are some frameworks concerning social-ecological systems and community resilience.

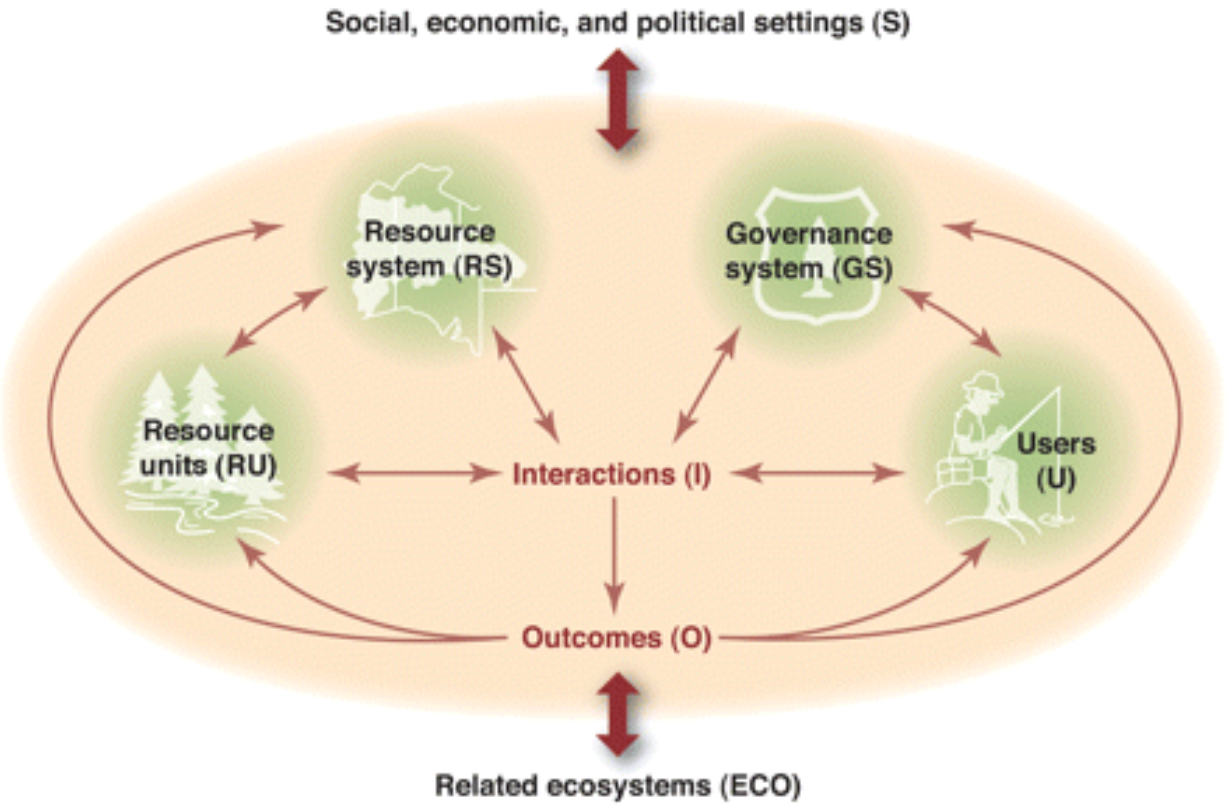
Resource Systems Approach

Societies, economies and communities dependent on environmental services and natural resources always have ecosystem, human and management/governance components to them. One cannot properly understand a coupled human-nature system without taking an integrated approach that incorporates these multiple considerations. Therein lies the basis for what is in fact a long tradition of viewing natural resource 'sectors', such as fisheries, forestry and mining, as systems. The figure below, adapted from Charles (2001), indicates the three components, the interactions among them, and some of the external drivers affecting the system.



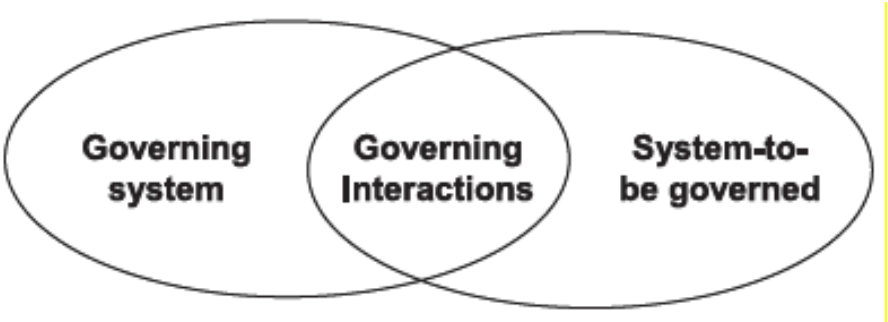
Framework for Analyzing Sustainability of Social-Ecological Systems

Ostrom's (2009) framework for analysing SES involves four core systems (see figure below) and a large number of variables falling under the core systems (see Table 1 of Ostrom 2009).



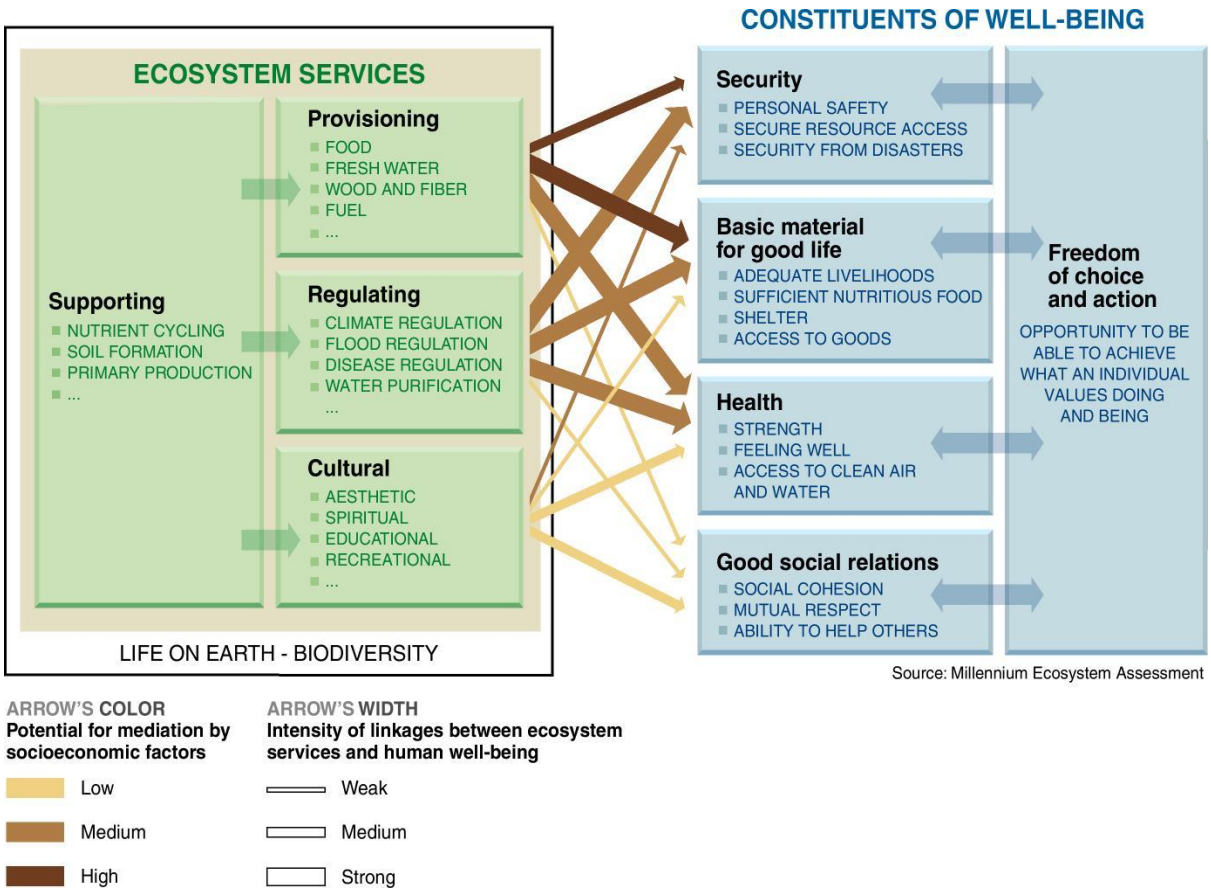
Interactive Governance Framework

Interactive governance theory holds that governance is broader than management in that, in addition to goals and policies, it includes the deliberation and determination of these goals, and the values and principles on which decision-making should be based [(Kooiman et al. 2005), (Jentoft and Chuenpagdee 2009)]. According to this theory, fisheries and coastal governance consist of three systems: a governing system, a system-to-be-governed (natural and socio-economic), and a system of governing interactions, linking the first two (Kooiman et al. 2005).



Millennium Assessment Framework

The large international project, Millennium Ecosystem Assessment focused on the relationships between ecosystem services and well-being (Millennium Ecosystem Assessment 2005). http://www.millenniumassessment.org/en/Synthesis.aspx

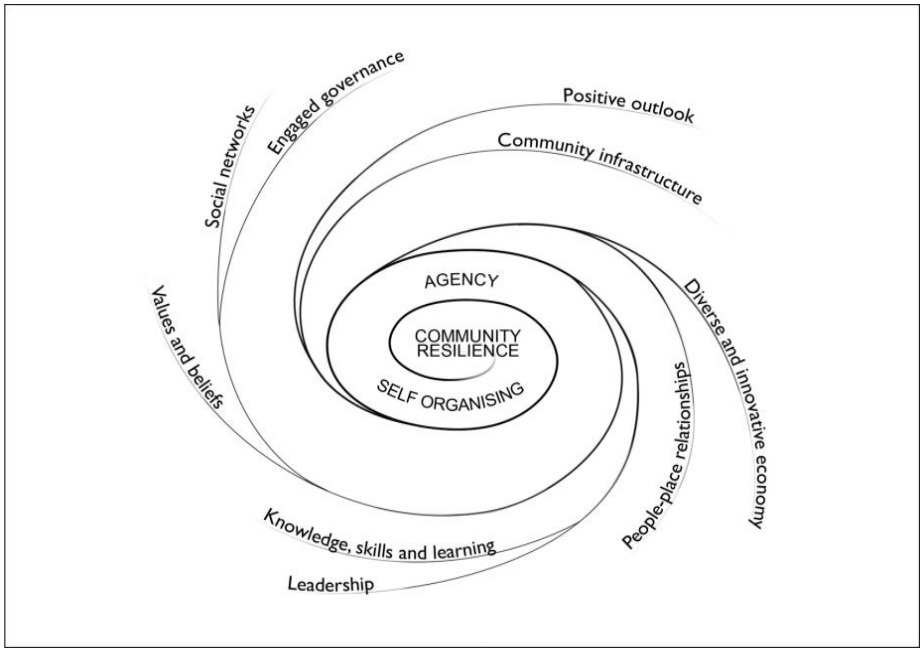


Sustainable Livelihoods Approach (SLA)

The SLA was one of the first efforts in addressing variables from a system which included rural people and their natural resource base (or a human-in-nature system). The approach is centered on people and is aimed at alleviating poverty through the enhancement of people's livelihoods. It includes assessing key components of the livelihood system -named as "assets" or "capitals" including the followings: 1) human capital, 2) social capital, 3) natural capital, 4) physical capital, and 5) financial capital, all which are represented graphically on the axes of a pentagon. It also includes a description of the vulnerability context for the addressed system as well as local people's livelihoods strategies, and desired changes to achieve specific livelihoods outcomes [see (Chambers and Conway 1992); (Scoones 1998); (DFID 1999) and (Carney et al. 1999)].

Resilience Assessment Workbook for Practitioners (Resilience Alliance 2010)
http://www.resalliance.org/index.php/resilience_assessment
The workbook uses a framework to conceptualize case studies as integrated social-ecological systems, and to evaluate the resilience of particular components of the system to shocks or stresses (abrupt or gradual change). Assessments typically involve participatory workshops with stakeholders and experts (1) to address the questions, resilience of what to what, considering drivers of change, disturbances and potential thresholds, (2) to develop a conceptual model of system dynamics, with focus on thresholds, feedbacks and alternate states, and (3) to identify sources of resilience and the capacity of the social-ecological system to adapt or transform.

Community resilience characteristics
Much of the literature on community resilience comes from the area of psychology of development, extended to community development. This literature emphasizes identifying and developing community strengths, and building resilience through agency and self-organization. Nine characteristics (or strengths) have been identified as important, leading to agency and self-organization in communities of place: people-place connections, values and beliefs, knowledge and learning, social networks, collaborative governance, economic diversification, infrastructure, leadership, and positive outlook. These factors do not apply to all cases. But they do provide a guide for resilience building at the community level: how can adaptive capacity, self-organization and agency be supported and fostered through processes such as community development and community based planning? Adaptive capacity and agency can be facilitated by community members themselves through social learning, or by external change agents (such as NGOs), using well known approaches in community development for building community strengths and relationships (Berkes and Ross 2013)

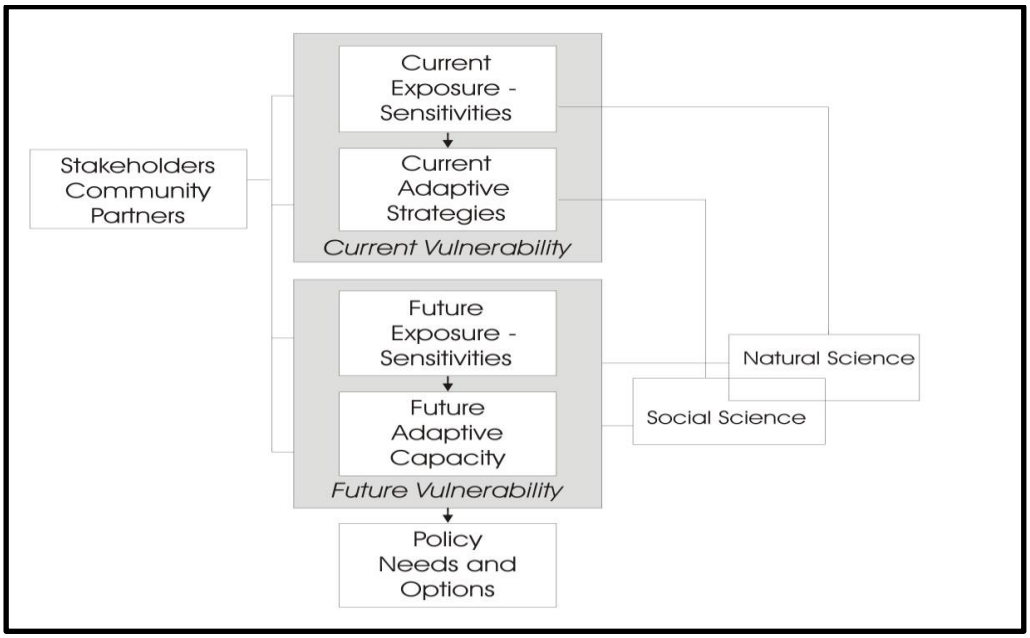


Social Wellbeing

Well-being is often framed as a desired target or an outcome, as in how it is used in the Millennium Ecosystem Assessment (2005). However, a social conception of well-being has been developed by the Research Group on Well-being in Developing Countries (WeD) (Gough and McGregor 2007). A social conception of well-being nests the individualistic and basic needs aspects of well-being within a broader understanding of the psychological and cultural needs required to live well (Deneulin and McGregor 2010). In this view, social well-being is an outcome and a process that considers three related dimensions of a life well lived: (1) a material dimension, (2) a relational dimension, and (3) a subjective dimension. Under this approach, well-being is not perceived just as a targeted or desired state of being - it can also serve as a framework for the analysis of human thriving. Importantly, the concept can be used to help unpack some of the main elements that drive people's choices and behaviour, or in CCRN terms, their meanings and motivations.

Vulnerability framework

There are four core components in the framework. The researchers first document past and **current exposure sensitivities** (question 1) in order to identify the conditions that are of particular relevance to the community. They also identify and document the **adaptations strategies and processes** (question 2) to describe the ways in which communities have managed the conditions to which they are exposed and sensitive. Together, these characterize current vulnerability. They also provide the basis for estimating future vulnerability (both **future exposure-sensitivity** and **future adaptive capacity**). This involves assessing the likelihood of changes in the conditions that are pertinent to the community, drawing on scientific predictions of change in natural and social systems and characterizing the scope and limits to adaptive capacity. The assessment of future risks and prospects for adapting provides the basis for collaboratively identifying **policy needs and options** and the initiatives that could enhance the capacity of the community to adapt (Smit et al. 2008).



Appendix 4: Video Resources

Community Conservation Research Network: “What is the CCRN” (2013) (00:05:11)
http://www.communityconservation.net/#nch/1417332437

Sarah Bood for the Coastal CURA: “A Coastal Partnership: Maritime Stories of Integrated Management” (2012) (00:21:02)
http://www.coastalcura.ca/film.html

Sarah Bood for the Coastal CURA: “Sharing the Waters, Saint John, NB” (2007) (00:31:27)
http://www.coastalcura.ca/film2.html

Steve Lansing: “What is a complex systems approach?” (00:01:14)
http://www.stockholmresilience.org/21/research/research-videos/1-31-2008-what-is-a-complex-systems-approach.html

Brian Walker: “What is resilience in people and ecosystems” (00:07:36)
http://www.youtube.com/watch?v=tXLMeL5nVQk&feature=player_embedded

Stephen Carpenter: “What is resilience?”
http://www.youtube.com/watch?v=d7-6ROI5k-s

Buzz Holling: “Resilience dynamics”
http://www.youtube.com/watch?v=FrNWUOmOHRs&list=FLiNjHdQUP4Abo2Pa4CC0UCA&index=244

Brian Walker: “Managing feedbacks in SES”
http://www.stockholmresilience.org/21/news--events/seminar-and-events/whiteboard-seminars/2-2-2013-managing-feedbacks-in-social-ecological-systems.html

Ian Mauro: “Climate Change in Atlantic Canada, Multi-Media Research Project” (2012)
www.climatechangeatlantic.com

Ian Mauro: “Nilliajut: Inuit Voices on Arctic Security” (2013) (*Nilliajut* was filmed in partnership with the national Inuit association ITK and Inuit youth filmmakers from Arviat.)
http://www.inuitknowledge.ca/content/nilliajut-inuit-perspectives-arctic-security-1

Ian Mauro and Zacharias Kunuk, co-directors: “Qapirangajuq: Inuit Knowledge and Climate Change” (2010) (Qapirangajuq documents Inuit knowledge and experience regarding climate change from an Inuit point of view.)
www.isuma.tv/ikcc

Chatelle Richmond: *Gifts from the Elders* (2013) (Movie on NW Ontario Ojibwa, focuses on health and land)
www.giftsfromtheelders.ca

Appendix 5: Other Resources

Community Conservation Research Network
http://www.communityconservation.net

Ecology and Society is an electronic, peer-reviewed, multi-disciplinary journal. Many of the papers within it are about social-ecological systems and resilience.
http://www.ecologyandsociety.org/

International Journal of the Commons is an electronic, peer-reviewed, multi-disciplinary journal. Many of the papers in it are about jointly managed resources, communities, collective action, and social-ecological systems.
http://www.thecommonsjournal.org

CAPRi Training Materials
Resources, Rights, and Cooperation
A Sourcebook on Property Rights and Collective Action for Sustainable Development
Published by the CGIAR Program on Collective Action and Property Rights (CAPRi)
International Food Policy Research Institute
http://www.capri.cgiar.org/sourcebook.asp

WorldFish Center http://www.worldfishcenter.org
WorldFish Center publications http://www.worldfishcenter.org/resources/publications

South Pacific Community, Traditional Marine resource Management and Knowledge Information Bulletin http://www.spc.int/coastfish/News/Trad/trad.htm

Locally-Managed Marine Areas (LMMA) Network
http://www.lmmanetwork.org/

International Collective in Support of Fishworkers (ICSF) and *Samudra*
http://www.icsf.net/

FAO Fisheries and Aquaculture Department
http://www.fao.org/fishery/en

Global Partnership for Small-scale Fisheries Research
http://toobigtoignore.net/

Coastal and Ocean Information Network
http://coinatlantic.ca/

Millennium Ecosystem Assessment
Synthesis reports
http://www.millenniumassessment.org/en/Synthesis.aspx
Global assessments
http://www.millenniumassessment.org/en/Global.html

Scenarios assessment
http://www.millenniumassessment.org/en/Scenarios.html
Bridging scales
http://www.millenniumassessment.org/en/Bridging.html

The community resilience manual. A resource for rural recovery and renewal.
Canadian Centre for Community Renewal
http://communityrenewal.ca/sites/all/files/resource/P200_0.pdf

Building resilience in rural communities
The University of Queensland and University of Southern Queensland
http://learningforsustainability.net/pubs/Building_Resilience_in_Rural_Communities_Toolkit.pdf

Regime Shifts Database
http://www.regimeshifts.org/

Wellcoast
http://www.wellcoast.org/

Wellbeing in Developing Countries Research
http://www.welldev.org.uk/