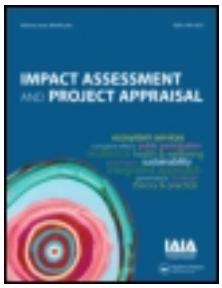

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Resilience thinking improves SEA: a discussion paper

Roel Slootweg [a] & Mike Jones [b]
[a] SevS natural and human environmental consultants, Terweeweg 20, NL-2341 CR, Oegstgeest, The Netherlands E-mail:
[b] Stockholm Resilience Centre, SE-106 91, Stockholm, Sweden E-mail:

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Resilience thinking improves SEA: a discussion paper

Roel Slootweg and Mike Jones
With contributions from Alan Bond, Susie Brownlie, Mark Fessey, Marie Hanusch, Art Hoole, Leonardo Marotta, Maria Partidário, Ulrike Pröbstl and Riki Therivel

Strategic environmental assessment is often referred to as a tool for predicting the consequences of planned development. The assumption of predictability of outcomes is inconsistent with reality which is characterised by uncertainty and complexity. Furthermore, the capacity of our life support systems to absorb disturbance and re-organise without changing into undesirable states appears to be of critical importance. Resilience thinking provides a structured way of looking at complexity, uncertainty and interrelatedness of systems and processes, and above all, provides us with new ways of dealing with planning and more effective use of SEA. Resilience thinking provides inspiration for those who want to extend their thinking about sustainability, but it also challenges some ideas underpinning the impact assessment profession (the future is unpredictable; change is inevitable; increasing stability leads to vulnerability). This paper is the result of a lively and well-visited workshop on resilience thinking and SEA at the 2010 IAIA conference in Geneva. It introduces the basic concepts of resilience thinking, and develops ideas for its integration within SEA practice.

Keywords: resilience thinking, strategic environmental assessment, social-ecological system, adaptive management, resilience assessment

STRATEGIC ENVIRONMENTAL ASSESSMENT (SEA) is referred to by conventional sources as a tool to predict the consequences of planned development. This positivist attitude towards the apparent predictability of outcomes is inconsistent with reality where, according to Longstaff (2009), 'one only need access the news media to become aware of an apparently never ending string of surprises'. In the months after the IAIA conference in Geneva where the discussion on SEA and resilience thinking was launched, we faced unforeseen events such as an Icelandic volcano stranding most Western European air traffic for days, severe floods in England, Poland, France and Central America, and the worst oil disaster in US history caused by one (only!!) leaking oil well in the Gulf of Mexico. Climate change as well as the world economy are examples of processes working at larger and mostly slower scales, yet producing unpredictable, sometimes rapid surprises such as the near-collapse of the global financial system in 2008. All those unpredicted events challenge the resilience of systems, some of which show increasing signs of pending collapse.

Alan Greenspan (2006, cited in Teigão and Partidário, in press) coined the current phase in which our society finds itself 'the age of turbulence'. The evolving energy crisis spreading its effects globally, the problems related to climate change, the

Roel Slootweg (corresponding author) is at SevS natural and human environmental consultants, Terweeweg 20, NL-2341 CR Oegstgeest, The Netherlands; Email: sevs@sevs.nl. Mike Jones is at Stockholm Resilience Centre, SE-106 91 Stockholm, Sweden; Email: mike.jones@stockholmresilience.su.se.

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demographic imbalances across different parts of the world, the environmental degradation, and the loss of fundamental ecosystem services are all trends that create 'tectonic stresses' accumulating beneath the surface of our societies. If combined and multiplied as cumulative effects, due to the greater interconnectedness of our global socio-ecological system, large-scale disturbances may be expected in future. Crisis, instability, interdependencies, uncertainty and complexity are words that characterise the current context in which the capacity of our life support systems to absorb disturbance and re-organise without changing into undesirable states appears to be of critical importance. Resilience thinking (Walker and Salt, 2006) provides a structured way of looking at complexity, uncertainty and interrelatedness of systems and processes, and above all, may provide us with new ways of dealing with planning and more effective use of SEA.

There are multiple definitions of resilience (Brand and Jax, 2007) but for practical purposes it can be simply defined as the ability of a system to absorb disturbance and return to its original state. Resilience models emphasise the unpredictable and complex nature of the ecosystems upon which people depend for survival, offering new insights into how they function and how they might be managed for sustainable use of their products and services to meet human needs. Complexity and unpredictability of social and ecological systems is largely a function of the self-organising, adaptive behaviour of living organisms, particularly the ability of humans to intuitively react to change, or to anticipate, plan and act for the future. These 'emergent' properties make system behaviour difficult to predict and require institutions for adaptive management that explicitly recognise uncertainty and enable a flexible management response. The notion of resilience has gained considerable attention in the field of disaster research (Steinführer *et al*, 2009). It has been identified within the social sciences as an approach that helps to better understand the occurrence of surprising events and attempts to give advice on how to expect the unexpected.

Resilience scientists coined the term 'social-ecological system' to emphasise the interdependence between humans and nature (Berkes and Folke, 1998). The concept can be usefully adopted to encourage more holistic and participatory approaches to planning, based on local as well as scientific knowledge. Systems with high adaptive capacity are able to re-configure themselves following a disturbance without significant declines in crucial functions. A consequence of a loss of resilience, and therefore of adaptive capacity, is loss of opportunity, constrained options, an inability of the system to do different things. The effect of this is an increased vulnerability of the social-ecological system and a higher probability that the system will undergo a fundamental and maybe even irreversible transformation into an undesirable state.

Resilience thinking provides new and useful concepts to deal with the interconnectedness of humans and their environment, the uncertainty and unpredictability of events at larger temporal and spatial scales that we need to look at when discussing sustainability, and provides management principles for this

As SEA is a strategic decision-making process we propose that incorporation of resilience thinking can bring significant benefits to the effectiveness of SEA. This paper is a first exploration of linkages between SEA and resilience thinking, based on a shared vision and common goal of sustainability among practitioners in both SEA and resilience communities. Resilience thinking provides new and useful concepts to deal with the interconnectedness of humans and their environment, the uncertainty and unpredictability of events at larger temporal and spatial scales that we need to look at when discussing sustainability, and provides management principles for this. SEA can provide the platform and procedural tools to actually implement these ideas. A sense of urgency to bring resilience thinking into SEA was felt at the 2010 IAIA conference, where a large number of people attended the first workshop on this topic.

This paper starts by introducing the basic concepts of resilience thinking, and then develops some ideas for its integration within SEA practice.

Resilience thinking

Resilience thinking is based on a number of core concepts, which are explained briefly below.

The adaptive cycle

The adaptive cycle (Figure 1) is a metaphor that describes change processes commonly occurring in both social and ecological systems (Holling and Gunderson, 2002; Holling, 2004). It comprises a 'fore-loop' (the familiar growth curve) and a 'back-loop' which describes the collapse of a system and the reorganisation of its components to provide the materials for renewed growth. The fore-loop represents a slow sequence of change from an exploitation phase as the resources for growth are accumulated, to a conservation phase where resources become progressively more locked up within the system's structure.

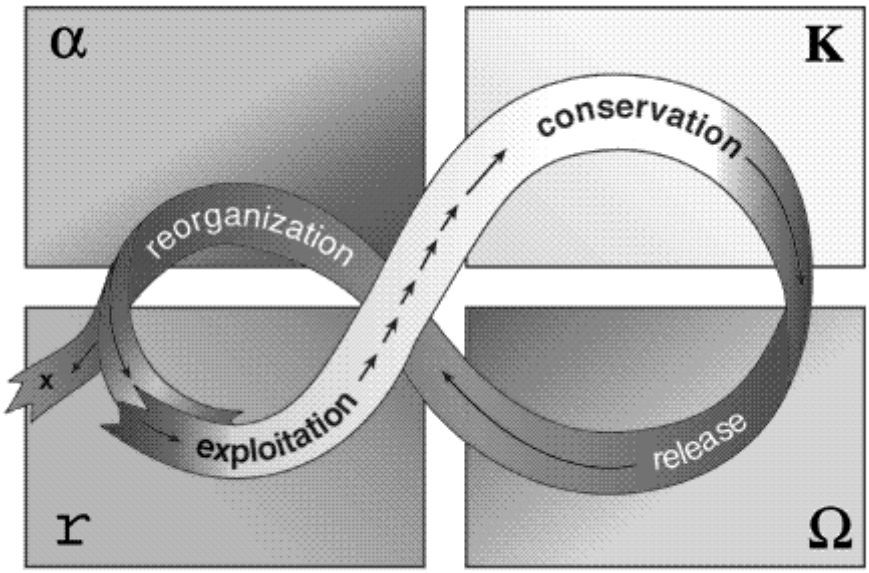

Figure 1. The adaptive cycle
Source: Holling (2004)

The back-loop represents a rapid collapse phase following a severe disturbance or shock that disrupts the system and releases resources, followed by a short re-organisation phase, which provides the opportunity for system reconfiguration before it enters a new period of growth. In a resilient system, re-organisation enables the system to return to its original state while an un-resilient system may be transformed into another state or decline into a poverty trap (the 'x' in Figure 1).

A common example of the adaptive cycle in an ecological system is the slow growth and accumulation of resources in a forest that collapses following a fire but regrows to its original condition, provided that there is sufficient potential for restoration within the larger landscape. A recent example from a social system is the collapse of some under-funded banks following multiple loan defaults and their re-organisation that was supported by massive low-interest government loans.

As both the forest and the bank examples imply, adaptive cycles operate within different levels of temporal and spatial scale, creating a nested and stabilising hierarchy where larger and slower components of the system provide the memory and resources for the recovery of smaller and faster components. A nested hierarchy of adaptive cycles is represented as a 'panarchy' (Holling and Gunderson, 2002; Holling, 2004) to explain the interaction between different ecosystem components operating at different levels of scale.

Panarchy

The panarchy was named after Pan, the capricious god of nature, to emphasise the unpredictability of interactions between ecosystem components in contrast to a commonly held deterministic worldview which regards ecosystems as ultimately predictable and controllable (Holling *et al*, 2002). Panarchy (Figure 2) considers the interplay between change and persistence and explains the apparent paradox of sustainable development: how things can change and yet remain more or less the same (Holling, 2001). The panarchy presents adaptive cycles for 'fast variables' that operate at small temporal and spatial scales and interact with adaptive cycles for 'slow variables' operating at large temporal and spatial scales. The scales vary from metres (or less in the case of single-cell organisms) to thousands of kilometres and from hours to tens of thousands of years. Adaptive cycles operating at different levels of scale are linked by 'revolt' and 'remember'

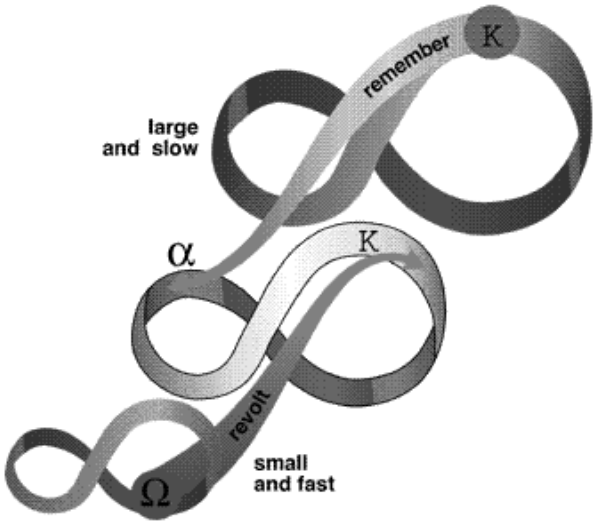

Figure 2. Connections between levels of a panarchy according to Holling and Gunderson (2002). Small and fast cycles can affect larger and slower ones (revolt) or large and slow ones can control the renewal of smaller and faster ones (memory)
Source: Holling (2004)

interactions. Revolt occurs when change at one level precipitates change at a higher level, while the remember interaction facilitates renewal and restoration at the lower level by drawing on the capital stored in the larger scale cycle. Cascades of collapse can occur if the remember facility of large-scale cycles is eroded by the actions of multiple fast variables.

The interactions between cycles operating at different levels of scale have important implications for management of social and ecological systems. Forest succession processes following a fire disturbance are dependent on the occurrence of forests at large scale and at different stages of successional growth to provide the seeds for regrowth (the 'remember' feedback). Human activities that reduce the extent of forests and the richness of forest species, and prevent the occurrence of fire in a misguided attempt to 'stabilise' forests, will tend to undermine their renewal capacity and push forest systems towards some threshold of permanent change. In the banking example, risky lending practices and debt accumulation undermined the ability of the banks to pay their debtors and depositors. When a sufficient number of homeowners defaulted on their loans, some banks collapsed but many were restored by loans from national banks. A cascade of collapse through the revolt mechanism, threatening the global economy, was averted by a stronger remember mechanism at the larger scale.

The dynamics of a system at a scale of particular management interest cannot be understood without taking into account the interactions between the focal scale and the scales above and below it. Maintaining slow variables is important for long-term stability and attempts to stabilise ecosystem processes by suppressing disturbance events like fire can reduce resilience. A particular example is the 2009 bushfires in Victoria, Australia, where risk was controlled based on a 1 in 50 year fire (Hughes and Mercer, 2009), with the result that larger scale fires could not be controlled and the damage to the social part of the socio-ecological system was catastrophic. This has implications for the timescale over which SEA assesses impacts.

Thresholds and alternate stable states

Many systems have one or more alternate stable states that are separated by threshold values that determine the condition of the system (Scheffer *et al*, 2001). All ecosystems are exposed to gradual change in things like climate, habitat fragmentation and species composition, and may adapt smoothly to these changes, but, as a consequence of their non-linear properties, can also flip abruptly into a different state; this is when synergistic impacts often occur. Resilience thinking assumes that social-ecological systems have alternate states (Figure 3) and exhibit abrupt change, as opposed to conventional environmental management that assumes

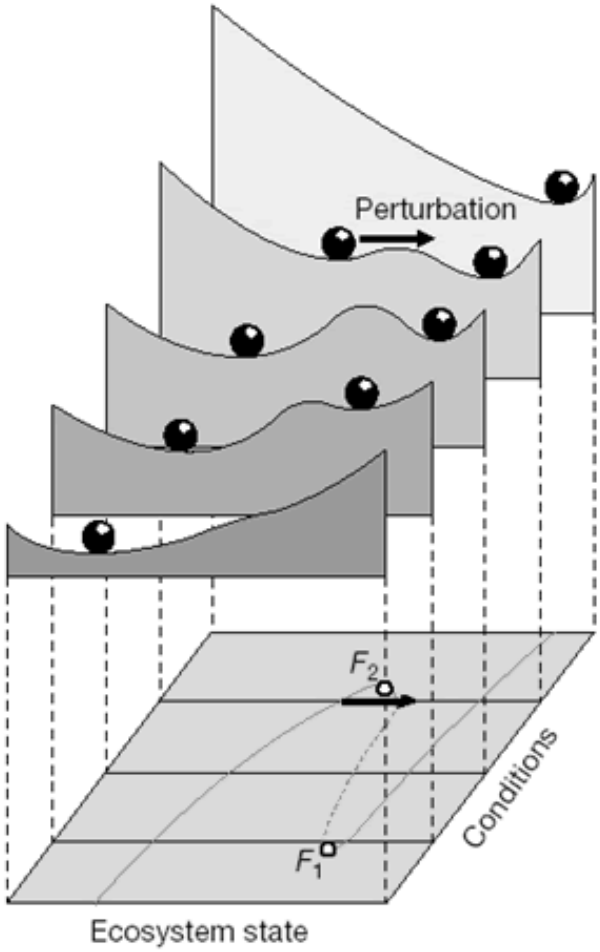

Figure 3. Ecological research has shown that, depending on environmental conditions, an ecosystem can have different stable states. A perturbation, be it a sudden event or a slow cumulative process, can cause the ecosystem to shift to an alternate stable state. Going back to the earlier state requires significant effort or energy. Resilience thinking applies the same concept to social-ecological systems.

Source: Scheffer *et al* (2001)

smooth and predictable change. When resilience concepts are applied to environmental problems, management is essentially about managing thresholds to ensure that the system of focal interest remains in the desired state or, when a system has flipped into an undesirable state, creating the necessary conditions to transform the system to a state that is desirable (Folke *et al*, 2004, 2009).

Social-ecological systems

Social-ecological systems are integrated systems of nature and human society with reciprocal feedback and interdependence. Although social and ecological components are identifiable, they cannot easily be separated for either analytical or practical purposes. The term ecosystem services (MEA, 2005) similarly highlights human dependence on and benefits from nature, and adds weight to the growing need to consider social and ecological systems as part of a bigger, complex dynamic.

Adaptive capacity

Adaptive capacity in ecological systems is related to biological diversity, and the heterogeneity of landscape mosaics. In social systems, the existence of institutions and networks plays an important role in adaptive capacity. Such institutions and networks learn and store knowledge and experience, create flexibility in problem solving and balance power among interest groups. In both ecological systems and social systems the importance of memory and self-organisation in the systems is critical in their capacities to adapt.

Systems with high adaptive capacity are able to reconfigure themselves without significant declines in crucial functions both in relation to the ecosystem services on which human well-being depends and in relation to social relations and economic prosperity. For instance, good social support networks have been shown to help avoid mental health problems such as depression (Sproston and Primatesta, 2003; Craig and Mindell, 2007), and places with low levels of social capital have been shown to cope less well in the aftermath of flooding than those with higher levels (Environment Agency, 2006). This resilience avoids crossing a threshold into an alternate, undesirable and possibly irreversible new state. A consequence of a loss of resilience, and therefore of adaptive capacity, is loss of opportunity, constrained options during periods of re-organisation and renewal, an inability of the system to do different things. And the effect of this is for the social-ecological system to emerge from such a period along an undesirable trajectory.

Resilience[1]

Ecological systems provide a range of services that benefit society and support human health and well-being. Resilience of ecosystems is thus an important attribute for sustainable use. Resilience is a property of these linked social-ecological systems (SES) and has three defining characteristics (Carpenter *et al*, 2006): (i) the amount of change the system can undergo and still retain the same controls on function and structure; (ii) the degree to which the system is capable of self-organisation; and (iii) the ability to build and increase the capacity for learning and adaptation. Ecosystem resilience is the capacity of an ecosystem to tolerate disturbance without changing into a qualitatively different state. Resilience in social systems has the added capacity of humans to anticipate and plan for the future.

The key to resilience in social-ecological systems is diversity. Biodiversity plays a crucial role by providing functional redundancy (species occupy similar niches and perform similar functions) and response diversity (sub-populations within a species respond differently to disturbance events) (Chapin, 2009). Similarly, when the management of a resource is shared by a diverse group of stakeholders decision-making is better informed and more options exist for testing policies. Active adaptive management whereby management actions are designed as experiments encourages learning and novelty, thus increasing resilience in social-ecological systems. Where it encourages futures thinking and the consideration of a range of scenarios and alternatives, SEA may increase resilience.

The challenges of managing socio-ecological systems

Social-ecological systems have some key attributes that make them intractable to conventional management approaches. For example, they have non-linear dynamics with thresholds. Interactions between people and nature at different levels of scale can thus lead to changes in ecosystem components that are neither predictable nor controllable. Furthermore, the effectiveness of management interventions depends on where a system is in the adaptive cycle (the fore-loop of development or the back-loop of collapse and re-organisation). Social-ecological systems are thus subject to complex problems for which there are no definitive or objective solutions; very often, the very application of a solution may in turn create problems. Although the outcomes of events in complex systems cannot always be predicted and complex systems cannot be controlled, they can be influenced and managed in an adaptive manner.

Participation and deliberation leads to trust and shared understanding; polycentric and multilayered institutions allow for more adaptive responses at appropriate levels (Folke *et al*, 2005; Anderies *et al*, 2006); accountable authorities that pursue just distribution of benefit to vulnerable groups enhance the adaptive capacity of society as a whole. Similarly, forms of social capital such as leadership, social networks and trust appear to be important aspects of adaptability and thus resilience.

Many of the problems encountered in managing natural resources arise because of a mismatch between the scale of management and the scale(s) of the ecological processes being managed (Cumming *et al*, 2006). Mismatches between the scales of ecological processes and the institutions that are responsible for managing them can contribute to a decrease in social-ecological resilience. Solutions to scale mismatches usually require institutional changes at more than one hierarchical level.

What does resilience thinking mean for SEA?

The characteristics of SEA provide an ideal vehicle for applying resilience thinking in practice, helping to distil out the key issues related to sustainability of both human systems and the ecological systems on which they depend. However, the complexity of social-ecological systems presents a major challenge for impact assessment practitioners who are

The characteristics of SEA provide an ideal vehicle for applying resilience thinking in practice, helping to distil out the key issues related to sustainability of both human systems and the ecological systems on which they depend

expected to make confident predictions and management recommendations.

This paper is intended to start a discussion on the value of resilience thinking for everyday practice in SEA for policy or plan formulation. When thinking about this, we ran into some problems. Firstly, it very quickly becomes obvious that one paper can only touch the surface of the subject; even an entire book would probably not be enough to cover the field. Yet, we see an urgent need to open the floor for this relevant discussion, as resilience thinking provides us with insights that may challenge some of the ideas underpinning our profession (the future is unpredictable; change is inevitable; increasing stability leads to vulnerability, etc.).

Secondly, the diversity of interpretations of SEA, ranging from re-active impact assessment via sustainability appraisal to pro-active opportunities and constraints analysis, makes it difficult to position resilience thinking within SEA. To be able to maintain some clarity, in this paper we consider policy formulation or planning as something belonging to a sector (transport, energy, agriculture, etc.) or to a territorial authority having a spatial planning responsibility. SEA is the process that pro-actively presses forward a sustainability perspective in the policy or planning process, or re-actively assesses the policy or plan against such perspective. Resilience thinking provides us with the latest and most far-reaching insights on how to reach sustainability in its broadest sense, and thus should be 'a SEA thing', with SEA being the vehicle to introduce resilience thinking in policy formulation and planning.

Resilience thinking has the potential to overcome some of the current weaknesses inherent in SEA. Bond and Morrison-Saunders (2011) identify some paradigms of strategic-level assessments which have implications for their effectiveness. In particular, where sustainability is the declared goal, the lack of focus on intergenerational equity, contested definitions of sustainability and tendency towards reductionism in assessment methodologies all affect perceptions of effectiveness. Resilience thinking provides a framework for identifying the appropriate timescale for consideration of social-ecological systems without the artificial constraint of an undefined 'intergenerational' equity factor. Such a focus on a social-ecological system can, potentially, overcome the issues identified with a reductionist approach (Bond and Morrison-Saunders, 2009).

Resilience is one of the sustainability sciences and is based on a specific mental model of sustainability that is defined by the panarchy and its subsidiaries, the adaptive cycle and regime shift model. Resilience models focus attention on change processes and explain how a system can change and remain the same through collapse and renewal at one level of scale, provided that the necessary social and ecological capitals are available at larger levels of scale for the renewal process. Sustainability is more broadly defined than resilience and open to many interpretations. A key point to remember with regard to both resilience and sustainability is that the environmental conditions that determine whether a system is resilient are in a constant state of flux, the rate of which varies with scale from small and fast to large and slow. The large, slow variables are those which impart resilience and sustainability over the long term and which human activity should seek to protect rather than to erode.

Before going into the more practical question on how to integrate resilience thinking in SEA practice, we first look at some typical SEA features for which resilience thinking can provide ideas to consider.

Integration from a resilience perspective

The concept of social-ecological systems in which the social, biophysical and also institutional environments are interlinked, creating one entity, puts the integration discussion in impact assessment in perspective. According to resilience thinking it is impossible to think of environmental assessment in the biophysical sense only, something which is still a common approach to environmental assessment. This leads to a 'trap of the expert' (Holling *et al*, 2002) based on a partial view of a system, leading to expert advice from within one discipline, partial solutions, crisis and political gridlock. The underlying causes are competing perspectives and disciplinary hubris. 'Experts' tend to focus on telling or doing what they know and to be poor at listening to alternative views, hence the resilience thinking view that transdisciplinary research and adaptive co-management approaches are an improvement.

The absolute minimum standard for SEA practitioners should be that specialist studies undertaken as part of a SEA must be undertaken collaboratively, rather than in 'silos', to ensure that the interdependencies between social and ecological systems are addressed in an integrated way.

Hierarchy of tiering versus panarchy of social-ecological systems

The well-known tiering of environmental assessment, in theory starting with assessment at policy

level, descending to plan and programme levels, ultimately ending with EIA at project level, is a multi-scale and hierarchical exercise. Tiering expects a linear cascade of rules and action from top to bottom, and obedience to and dependence on upper level decisions to ensure that project development at lower levels fits within the prescribed framework . In practice, however, emerging issues and changing routes occur during the implementation process to such a level that tiering often remains no more than an abstraction.

Resilience thinking introduces the concept of panarchy and the interaction of adaptive cycles at various scales. Through 'revolt' and 'remember' interactions (Figure 2) different levels interact as mechanisms of change, or of stability. This strongly suggests that no matter what the level of scale on which interest is focused, SEA should consider the interaction between that level and levels above and below. It is the cross-scale interactions that are often the cause of management failure. We need to be careful, however, not to confuse the impact assessment hierarchy with levels of temporal and/or spatial scale in the panarchy model. Hierarchy refers to different levels within a command-and-control management structure, while the panarchy refers to processes that operate at different scales: small and fast versus large and slow.

SEA usually is not focused on a panarchy of different spatial and temporal scales. The context for assessment processes at different decision-making tiers are constrained by administrative boundaries (such as municipality or national boundaries), and by plan timescales restricted to, typically, 10–15 years (Bond and Morrison-Saunders, 2011). Application of resilience thinking encourages consideration of the need for management institutions that match the scale of management with the ecological scale of the resources being managed.

Alternatives tested against scenarios

The resilience community proposes scenario planning (Peterson *et al*, 2003; Carpenter *et al*, 2006) as a way of determining strategic direction and also potentially as a basis for developing quantitative models that attempt to predict outcomes. Scenario planning explicitly considers a range of possible futures, rather than focusing on the accurate prediction of a single outcome. The intention is to provoke consideration of how critical uncertainties may affect the future (Biggs *et al*, 2009). Scenario planning in this respect is closely linked to the development of alternatives in impact assessment, used as a means to compare the consequences of different plan options, qualitatively or quantitatively, and often considered one of the strong assets of impact assessment.[2] Alternatives in this respect relate to planned actions, while the scenarios can encompass different futures taking into account external developments (in impact assessment often referred to as autonomous development). A matrix of alternatives against scenarios provides the assessment task.

Authors distinguish between different types of scenario: projective scenarios are those that portray futures which are likely to occur within certain confidence boundaries; prospective scenarios are those that are possible (what the future could be like), but for which uncertainty is great (Nassauer and Corry, 2004). For resilience thinking, the use of prospective scenarios has more potential to accommodate the resilience panarchy as they can vision situations which lie beyond the value-driven vision of citizens, or policy-constrained visions of expert stakeholders. Scenarios can be seen as tools for determining broad goals or strategic directions. Adaptive management then becomes the act of navigating the thresholds of change identified in the resilience assessment so as to avoid thresholds to undesirable system states, or to deliberately transform a system into a new desirable state.

The need for monitoring and learning

Resilience thinking re-emphasises the need for monitoring, but goes one step further. Resilience thinking attaches great value to learning. The capacity to adapt and to manage resilience requires learning, especially in arenas of collaborative learning using a combination of various sources of information and knowledge. Both social processes and actors (e.g. knowledge brokers) are needed to combine information and knowledge from multiple sources and a range of scale through experimental approaches such as adaptive management (Walker *et al*, 2006; Sheate and Partidário, 2009).

Learning goes beyond determining whether objectives were met and includes an evaluation of the assumptions underlying the development model (Chapin *et al*, 2009). Prediction of longer term and unforeseen perturbations is impossible, yet these can lead to a very different context in which the application of a policy leads to inappropriate results due to changes in key relationships in the system of focal interest. Consequently, one has to consider changing the policies. According to Yorque *et al* (2002) the most pragmatic approach is one based on 'learning our way into sustainable futures', rather than planning our way. (Note the 's' in futures — as stated earlier, many roads towards a sustainable future are available.)

A major implication of resilience thinking for SEA is the necessity to acknowledge complexity and unpredictability. This is a novel way of addressing SEA that has until now been underpinned by the notion of prediction. Essentially, resilience thinking posits that the systems are complex, uncertain and unpredictable. Hence, managing development to retain system resilience requires ongoing attention to auditing, monitoring and adaptive management as part of an ongoing environmental assessment process. Theory says environmental assessment is an

ongoing process. Practice, however, shows that once a project or plan is approved (or licensed) the necessary follow-up during the lifetime of the project or plan (such as lower level EIA, mitigation, monitoring or auditing) is often neglected, for many reasons.

'Contextual indicators' may provide a means to monitor for unforeseen effects, by measuring changes in the context within which the plan is implemented (Hanusch and Glasson, 2008). Variables on which the plan has minor influence provide information on key changes in the wider social, economic and environmental background against which the plan is being implemented. The main question for the SEA community in this respect is: how do we motivate developers, policy makers, etc. to (a) do the monitoring and (b) do the deeper kind of evaluation and learning that resilience thinking implies?

Institutional aspects

Adaptive co-management is an emerging approach for governance of social-ecological systems. Key features of adaptive co-management include a focus on learning-by-doing; synthesis of different knowledge systems; collaboration and power-sharing among community, regional and national levels; and management flexibility. Participation of direct stakeholders and inclusion of their knowledge is a crucial element in such approaches. These features can promote an evolving, place-specific governance approach in which strategies are sensitive to feedback and orientated towards system resilience and sustainability.

Recent research on the detection and aversion of thresholds of undesirable change (Biggs *et al*, 2009) suggests that they are difficult to predict and difficult to avoid except in the case of 'fast variables' under conditions where a rapid and appropriate management response is possible. The implications are that governance units should be built on small local jurisdictions that scale up where necessary to manage resources with large-scale ecologies, and that large bureaucracies are incompatible with resilience. In other words, these findings are an additional argument for developing adaptive co-management institutions and polycentric governance systems. A third implication is that the role of central government has to change from command-and-control through 'one size fits all' policies to one of facilitation of the emergence of adaptive capacity of governance entities that are scaled to match the resource being managed. The necessity for policies that protect the conditions of emergence of adaptive co-management was identified by Ruitenbeek and Cartier (2001) and a devolutionary approach is advocated as a biodiversity conservation policy response to climate change in Australia (Steffen *et al*, 2009).

Consequently, in SEA more emphasis is needed on governance, institutions and the level of management with regard to society's ability, commitment and preparedness to manage systems for resilience. Similarly the role of public participation and the use of local knowledge has to be reinforced in SEA. Too often SEA is, given its strategic nature, considered a task for government officials and experts. Intermediary outcomes are treated as politically sensitive that should not be open for public debate. Furthermore, it should be recognised that the process of engagement and participation can itself contribute to the development of social capital and learning, and thus contribute to social resilience.

How to integrate resilience thinking in SEA

We now have arrived at the question: what help is available to integrate resilience thinking in a practical manner in day-to-day SEA, or how to do SEA with a resilience lens? We will present existing approaches that provide help from different angles. First we will look at a tool to assess the resilience of a particular area or situation, including a possible procedural framework for resilience thinking in planning contexts. Next, nine values for a resilient world are provided that may serve as a yardstick for SEA.

Resilience assessment

One of the most practical tools developed by the resilience community is the resilience assessment workbook (Resilience Alliance, 2010) that was developed concurrently with a resilience-based sustainability assessment of an Australian water catchment (Walker *et al*, 2009). In a nutshell, resilience assessment is a process that does the following:

(1) Defines the resilience of what to what:

- System boundaries: spatial and temporal scale; stakeholders; variables of concern including important ecosystem goods and services; resource trends; historical time-line; present and future management issues.
- Governance: who decides; who uses; regulating institutions; equity issues; conflicts; scale mismatches and cross-scale interactions.
- Disturbances: patterns of ecological and social disturbance; driving variables; disturbance events.

This phase of the assessment is a collaborative and iterative process where the historical time-line can provide a useful description of the scale and frequency of events that have shaped the present system and lead to a refined definition of the spatial and temporal boundaries of the system, and identification of the major drivers of system change. This part of a resilience assessment is similar to other planning and strategy development tools but differs significantly in the way that it considers social and ecological interactions across multiple levels of scale, the governance implications of matching (or mismatching) the scale of ecological processes with

regulatory processes and the shifting patterns of change over time.

(2) Describes the alternate states and thresholds of the system:

- Describe the alternate states for ecological and social components of the system of focal interest.
- What are the thresholds between these states and what are the consequences of crossing these thresholds?
- Identify the drivers pushing systems towards thresholds.
- What are the positive and negative feedbacks regulating driving variables?

This second phase of the resilience assessment is what distinguishes the outcome from standard linear predictive planning and assessment processes and is perhaps the most significant contribution of resilience thinking to environmental assessment processes. It requires an understanding of the systems driving variables and the control points that exert positive (self-reinforcing) or negative (self-regulating) influences on those drivers. It defines past and potential future alternate stable states for the system and enables management to chart a course to avoid identified thresholds that are deemed undesirable or to restore a desirable system to its previous state, if other factors are conducive to such a recovery.

A complete resilience assessment would conclude with quantitative models of thresholds of concern to management but it might also be usefully concluded with the development of scenarios for a range of possible futures. What comes next depends on the underlying purpose of the assessment: policy analysis and development; landscape planning; development planning; active adaptive management experiments; network development, etc. The resilience handbook developed by the Resilience Alliance (2010) is presently being revised to address these different possible uses.

Management and policy interventions will thus vary according to the underlying purpose and context of the resilience assessment but in general will consider:

- The kinds and scales of intervention with regard to the focal system's position in relation to the phases of the adaptive cycle and in relation to the adaptive cycle phase of systems above and below the focal scale.
- The need for a fundamental transformation of the system to a more desirable state as opposed to enhancing the resilience of the existing system.
- The sequencing of interventions to mitigate risk of collapse during a transformative change.

Ideally, management and policy interventions would be undertaken within an adaptive co-management framework which brought the affected parties together to build trust, improve problem solving and develop a framework for adaptive learning and the development of new policies. Adaptive co-management enables 'nested enterprises' where 'appropriation, provisioning, monitoring, enforcement, conflict resolution and governance activities are organised as multiple layers' (Dietz *et al*, 2003). This overcomes problems of one size fits all policies that do not fit at the local level because of contextual variation. It also provides a basis for 'double-loop learning' (Chapin *et al*, 2009), in which the adaptive cycle is closed by evaluating the underlying assumptions of a policy as well as the outcome of the management activity itself so that policies become experiments in environmental management that improve our understanding of the system.

Apart from resilience *of what*, and *to what*, Lebell *et al* (2006) add a third aspect of relevance to SEA: 'In exploring the sustainability of regional social-ecological systems, we are usually faced with a set of ecosystem goods and services that interact with a collection of users with different technologies, interests, and levels of power. In this situation in our roles as analysts, facilitators, change agents, or stakeholders, we not only need to ask: The resilience of what, to what? We must also ask: *resilience for whom?*' Such attention, for example through prioritising the most vulnerable parties, would benefit SEA and help to improve social-economic equity and sustainable livelihoods.

An approach aiming to integrate resilience thinking into strategic planning, is the SPARK approach, developed by Teigão and Partidário (in press). This Strategic Planning Approach for Resilience Keeping (SPARK) 'explores resilience as a concept and as a framework for promoting more sustainable trajectories, highlighting its potentialities and advantages for policy and planning processes'. Keeping in mind that there is not one recipe, formula or perfect way to apply resilience thinking, the authors provide a generic procedure representing the key principles of resilience thinking in a logical sequence of steps derived from the characteristics of a planning process. Of course, the framework is to be adapted according to the system or problem addressed. The steps laid out are consistent with a resilience assessment. Planning for resilience is neither about creating new formal plans nor about introducing new orientations, but it is instead about how to raise awareness in relation to a more 'open-mind-to-change' perspective, critical when dealing with uncertain realities even in more traditional planning contexts. The transition from 'command-and-control' to 'learn-and-adapt' also lends more importance to a 'put-people-in-the-process' perspective and less relevance to a 'paper-plan-production' process.

When strategic planning is not (yet) equipped with the principles of resilience thinking, SEA is a vehicle to bring resilience thinking into the planning process, for example by proposing a resilience assessment. It is difficult, however, to envisage a

resilience assessment as a distinct activity within the larger process. As shown in the earlier sections, resilience thinking has all-encompassing implications for a SEA process, be it the mind-set of participants, the kind of stakeholders involved, the applied methodologies, the type of monitoring and follow-up, or the very objectives of the policy to be assessed. Applying a resilience assessment thus implies that the entire SEA process is based on resilience thinking. The next approach may be helpful in directing the SEA process into the direction of resilience thinking.

Nine values for a resilient world

Walker and Salt (2006) provide nine values for a resilient world which can be used to assess the impacts of a proposed policy, plan or programme on the resilience of a social-ecological system. Gaudreau and Gibson (2010) adapted Walker and Salt's (2006) values to create nine criteria for resilient societies and integrated these with Gibson *et al*'s (2005) generic sustainability criteria in the evaluation of a small-scale biofuel project. The nine values can be similarly used as a yardstick against which existing SEA practice might be assessed with a view to developing improvements in SEA processes. The summary below tries to look at these values from the perspective of present SEA practice.

1. Promote and sustain diversity in all forms (biological, landscape, social, and economic) The need to conserve biological diversity is addressed by a UN Convention, is subject to legislation in many countries, and receives serious, though fragmented, attention in impact assessment (see Slootweg *et al* (2009) for an in-depth overview). Diversity is not recognised as a good thing *per se*, but usually is limited to legally protected species. Landscape diversity receives some attention in impact assessment where it concerns valued landscapes (e.g. for scenic beauty and/or traditional land-use practices). Even though landscape diversity as such is not considered very relevant within the SEA, new approaches based on the European landscape convention underline this aspect and its importance. While the European legislation sets up the framing conditions, social and economic diversity have not been defined within SEA yet. Experiences with sustainability appraisal showed that the combination of all these aspects in one framework is not perceived to be very successful (Therivel, 2010). Social and economic diversity have not been defined at all yet for impact assessment purposes.

2. Embrace ecological variability rather than control it The common trend with planning and development is to use technology and fossil fuel energy to make systems more stable and more predictable. Among other things this is necessary to reduce risks and encourage investment. There is a growing counter movement of environmental restoration that seeks to re-establish ecosystem functions that have been lost. Good examples are available in water management where there is a tendency to create more room for variability and natural processes in watersheds. The Room for Rivers programme and SEA process in the Netherlands are a good example. In this programme some of the possible measures are combined with other environmental benefits such as nature restoration or landscape improvement. The SEA was meant to enable planners and decision-makers to find the best possible compromise of safety, environmental benefits and costs (Verheem and Laeven, 2009).

3. Maintain a degree of modularity or disconnectedness Where ecological connectivity, in the sense of maintaining corridors of habitat for animals and plants to move across highly modified landscapes, is considered a thing to desire, other types of connectivity can be undesirable. Think of the rapid spread of contagious diseases in a globalising world (quarantines to create disconnectedness), or the global financial system where one problem (mortgages in the USA) almost brought down the entire global banking system. In general, there needs to be some kind of balance between connectedness and disconnectedness. In SEA practice the issue hardly ever goes beyond physical connectivity (think of compartmentalisation to control floods or fires, or ecological corridors). The more complex issues related to institutional arrangements for modularity, or the social or economic risks associated to globalisation are hardly ever addressed. Impact assessments of trade negotiations are probably the best example of an attempt to provide a view on the potential impacts of liberalisation of globally traded commodities. One of the overarching problems in SEA in this respect is the disconnectedness of expert studies hindering a good overview of interrelationships between issues. Only a serious discussion of interrelationships can contribute to the idea of modularity and disconnectedness.

4. Recognise the importance of slow variables like nutrient, carbon and water cycles Resilience thinking within SEA can focus on these aspects at a very early stage of planning, simply because at a higher policy or plan level it is possible to take slow variables into account to set the bandwidth of action for lower level plans and programmes. The important point from a SEA perspective is being able to recognise 'thresholds of potential concern' so that development is undertaken with due caution, and is possibly preceded with modelling and active adaptive management experiments to learn more about the threshold so that it may be avoided.

5. Create tighter feedback loops between human actions and environmental outcomes This is about monitoring and being able to adapt or transform a system before undesirable thresholds are crossed. Consider the following contrasting situation. In a

small-scale rural system everyone is constantly aware of their dependence on ecosystem goods and services and how fluctuations in these affect their lives. Monitoring tends to be constant and informal. Corrective management actions consistent with local knowledge are taken in response to environmental fluctuations. In large-scale urban systems life supporting services come from the supermarket. The link between ecosystems and human well-being has been broken, so there is no feedback linking consumers to the natural environment upon which they depend. Without negative environmental feedback, overconsumption is inevitable: that is until some major and possibly catastrophic feedback (such as global warming) does kick-in and exert a corrective effect. This is directly linked to the commonly signalled failure in impact assessment to properly address monitoring and corrective follow-up action; though the issue is now receiving increased attention.

6. Promote trust, well-developed social networks and leadership Even though the implications of this value go far beyond the boundaries of SEA, there are some obvious things that SEA has to promote. Trust is directly linked to transparency in a planning process. Government agencies have a tendency to keep planning processes behind closed doors until they have created a plan. Instead of sharing their problem with other stakeholders in society, they present a plan for something of which the need has not been discussed yet and thus may not be obvious. The lack of transparency during the process leads to suspicion among 'outsiders', a defensive response from the proponent of the plan, deadlock, and in the end court cases. A genuinely participatory approach can solve many of these problems, and may provide relevant additional information for the planning process.

It goes without saying that a successful participatory process contributes to the creation of active social networks (incidentally, successful opposition against a proposed plan also leads to strengthening of social networks).

7. Emphasise experimentation, learning, locally developed rules, and change Application of resilience thinking implies some major transformations of the social component of social-ecological systems, including the adjustment of mental models that are no longer appropriate and the creation of new governance systems in 'triple-loop learning' (Chapin *et al*, 2009). From a SEA perspective this resilience value means paying more attention to monitoring and evaluation so that every development is treated as a learning opportunity rather than the delivery of *the* answer to the problem. A strong SEA asset not used to its full potential is the use of alternatives that can be identified when scenario planning is used as part of a resilience assessment. Thinking in terms of alternatives provides a means to accommodate opposing views of stakeholders and enhances creativity and learning during the process. A major problem is the attitude of most decision-makers, who want guarantees based on hard figures, not fuzzy planning with uncertain outcomes. The question is whether we will be able to reorient SEA, without having to reorient society as a whole. A hopeful example comes from new approaches in spatial planning, or development planning, where emphasis nowadays is put on the planning process itself and less so on the outcomes. The process aims at analysing the constraints and opportunities provided by the biophysical environment in relation to the needs and aspiration of its inhabitants/users in a dynamic environment (e.g. Rooy *et al*, 2004).

8. Develop overlapping institutions to increase response diversity and flexibility to change Management systems for water, fisheries, migratory wildlife and other highly mobile resources are all likely to have examples of overlapping institutions. In the water management sector (irrigation in particular) there is discussion on the need to create polycentric governance structures. Institutional context has traditionally been a weak aspect of SEA. However, the World Bank has championed an institution-centred approach to SEA, which could provide an entry point for resilience thinking from an institutional point of view. The premise behind this type of SEA is that at a more strategic planning level the planned actions are more abstract, and the direct relationships between these actions and concrete impacts is more difficult to identify and describe. Rather than attempt to assess impact, SEA at this level should assess the institutional context within which the policy is developed and implemented (Kolhoff *et al*, 2009: 148). Questions for such a SEA could be: how to avoid sectoral blindness; how to involve a broader 'audience' in the process; and how well equipped is the institutional capacity to manage environmental impact and to take advantage of environmental opportunities? Reflective evaluations of this kind are part of both double and triple-loop learning.

9. Include all the un-priced ecosystem services in development proposals and assessments Since the Millennium Ecosystem Assessment this subject has received serious attention, even though it has not reached many policy and planning processes yet. The trend is definitely in the right direction. The SEA guidelines adopted by the Convention on Biological Diversity provide a framework to work from (CBD, 2006; Slootweg *et al*, 2009).

By using the above nine values as a reference for assessment, we claim it is possible to assess whether a policy or plan is good or bad from a resilience, or even from a sustainability perspective (assuming that we have enough knowledge to make a proper judgement on each value).

The field of resilience thinking is developing rapidly and provides a rich source of inspiration for those who want to extend their thinking about sustainability and how to reach a more sustainable world

Concluding remarks

In this paper we have tried to provide a very short overview of what resilience thinking is about and insight on possible linkages with SEA. We do not pretend to have treated the subject in great depth and we note that, while impact assessment professionals are beginning to make use of the concepts of resilience and social-ecological systems in relation to sustainability assessment (e.g. Haywood and de Wet, 2009), little of this appears to be published, applied to cases or developed to any depth. The field of resilience thinking is developing rapidly and provides a rich source of inspiration for those who want to extend their thinking about sustainability and how to reach a more sustainable world. The conversation that led to this discussion paper included many questions about the meaning of resilience concepts, the jargon that has developed to define those concepts and the relationship between resilience, resilience assessment and the broader field of sustainability and sustainability assessment.

Resilience concepts are being developed and, for example, terms such as 'threshold' and 'tipping point' tend to be used interchangeably. Adequate exploration of these emerging concepts and the relationship between resilience and sustainability will require considerably more discussion than can be covered in a single introductory paper. We have tried to show that resilience thinking provides insights relevant to sustainability and that resilience assessment is a practical tool for the pursuit of sustainability. The nine values for a resilient world are a good starting point to think about translating resilience in a SEA context, even though new scientific evidence will lead to further adaptation and refinement of these values. From the procedural perspective the SPARK approach provides a starting point to position resilience contents in a planning context.

Of course, the proof of the pudding is in the eating. We hope the impact assessment community is interested to translate all of the above in practical reality. There is an obvious need to combine sound scientific research with the practical translation for real-world application of resilience thinking in (the assessment of) policy and planning processes. The challenge in this respect does not lie with the assessment tool or procedural aspects; we probably have enough of that and definitely do not want to develop new frameworks. The real challenge lies in people's ability to accept a different mental model that embraces complexity and uncertainty in management and development. We may even conclude that there is no need for any 'new' kind of tool, nor new steps, but simply acknowledge the need for a fundamentally new way of looking at things.

Naturally, we all would like to know what a resilient world would look like. Yet, this would lean towards prescription, which is a feature of command-and-control governance. One of the major points about resilience thinking is that it aims to encourage people to develop their own systems to suit their understanding of their environment. This builds response diversity and adaptive capacity. In this respect, the impact assessment community represents an ideal mix of scientists, practitioners and planning authorities to develop their own ways to deal with resilience in SEA and planning. And probably there are many different ways in which resilience can be taken on board, depending on context, capacity, creativity and consciousness. We ask for response, practical case material, and deepening of the debate.

Notes

1. Gallopín (2006) argues that resilience is a subset of adaptive capacity, which is in turn a subset of vulnerability. Put another way, a system can have high adaptive capacity (biodiversity, redundancy, social diversity, modularity, etc.) and still not be resilient to certain kinds of shock. Other attributes that affect a system's vulnerability are its sensitivity and exposure to disturbance. Vulnerability is the degree to which a specified system is likely to experience harm due to exposure to a specified risk or stress (Adger, 2006). In a sense vulnerability could be considered the 'flip side' of resilience. However, the link between resilience and vulnerability is complex and both concepts are discussed widely in different scientific contexts. Without going into any detail, we would like to point out one thing. There is a tendency to look for 'the silver bullet' that will solve all problems. Although resilience thinking offers useful improvements to environmental management processes, it is not a panacea for vulnerability issues or other kinds of environmental management problems (Ostrom *et al*, 2007).
2. With respect to development of alternatives, resilience thinking provides an additional advantage, that is the identification of potential 'points of intervention'. These may be applied at any point on the fore-loop of the adaptive cycle from r to K to deliberately induce a phase of creative destruction aimed at either rejuvenating a system or breaking up an undesirable system and transforming it into something different. Fore-loop interventions are broadly aimed at preventing a system from entering a rigidity trap and becoming maladaptive. Back-loop interventions are applied in the alpha-phase and are firstly aimed at restoring order from the chaos that follows a collapse and then either waiting for the original system to re-emerge (*laissez-faire* management) or deliberately introducing some innovation(s) that transform the system by changing its components or the relationships between them.

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