The use of scenarios in adaptation planning: managing risks in simple to complex settings

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Abstract

This paper investigates how scenarios applied within a risk-based context can assist in adaptation planning and implementation. Tame and complex risks are identified. Tame risks are characterised by widely agreed conceptual framing, bounded values and an established process for calculating risk. Complex risks are characterised by wicked system properties characterised by the social amplification of risk, very different perceptions of risk and great uncertainties in calculating risk. The word risk also changes from a noun assessing what is at risk, to a verb, to risk for gain. Different weightings are placed on loss and gain as measured by behavioural economics, which affects the perception of risk. Scenarios applied to tame risks aim mainly to gain a common understanding of what is at risk and risk treatment options amongst different groups. Scenarios can be applied to complex risks in three stages: scoping and risk identification, risk analysis and risk management. In the scoping and risk identification stages, top-down exploratory scenarios identify a range of risks for further analyses. In the analysis stage, the focus switches to the scale of the system and how it functions, and may involve the use of exploratory and normative scenarios to describe a range of futures. For the risk management, or adaptation, stage, scenarios are largely normative and focus on developing adaptation actions and adaptive capacity, seeking positive, enabling outcomes. Finally, the notion of reflexive scenarios is discussed. They aim to explore management options in a reflexive manner by creating and maintaining scenarios in a 'live' setting. Reflexive behaviour involves constructing scenarios that scope and analyse risk and risk management options, updating normative goals based on new information. Ongoing monitoring learns from both success and failure, tracking existing and emerging risks, and periodically revisiting the scenarios to update them. In this situation, the scenarios are owned by those who are undertaking adaptation.

Introduction

This paper is one of three written for the project *Clarifying and mapping the use of scenarios in climate change adaptation strategies for the state of Victoria*. The other two are *What is adaptation?* (Rickard, in prep) and *Scenario praxis for systemic and adaptive governance* (Ison et al., 2010).

Here, I propose a framework for applying adaptation scenarios within a broader framework of applying scenarios to complex risks. Scenarios are tools for aiding decision-making under uncertainty. Beyond that their role is diverse and they can be put to a great many uses.

A cognitive model is used to identify three phases within the risk assessment process where scenarios are most suitable: scoping, risk analysis and risk management. The scoping phase selects the area of interest, constructs idealised risks and scopes risk for further analysis. The analysis phase assesses impacts and vulnerability for a range of climate-related risks, or a more generic set of risks where changing climate plays a role. The management phase centres on adaptation to climate change. Adaptation itself will occur in many settings from simple to complex.

Four areas of scenario development are identified: one for each of the three phases above and a fourth, a reflexive interventionist multi-actor based scenario introduced by Wilkinson and Eidinow (2008) designed to promote ongoing adaptive management in complex settings.

A brief history of climate change scenarios

Because climate scenarios are quantified they have been criticised as being inconsistent with the history and intent of scenarios as a planning tool. Scenarios are often thought of as being subjective, narrative-driven story lines that aim to explore a wide range of possibilities than the classical projection of current trends. In particular, the idea that projections from scientific models qualify as scenarios is often challenged, as discussed by (Schnaars, 1987).

However, climate change scenarios came from the same tradition of the Club of Rome *Limits to Growth* (Meadows and Club of Rome., 1972) of global scenarios testing exploratory futures. The earliest climate scenarios date from the 1970s (e.g., (Aspen Institute for Humanistic Studies, 1978; Flohn, 1979). These were part of a larger family of scenarios foresighting global trends that were being constructed during that period. Such scenarios are still being built. Therefore, the origin of climate change scenarios lies in the classical tradition of using scenarios for long-term planning.

The application of climate scenarios within a scientific context also dates from this time. The notion of scenario plausibility was interpreted as requiring climate scenarios to be scientifically plausible (Pittock and Salinger, 1982), putting climate scenarios on the path to quantification. Climate scenarios were also applied through analogues of past climate to inform future climate. (Glantz, 1991) points out that such tools have both a heuristic or learning role and a scientific role in being able to propose and test hypotheses about climate change and the accompanying impacts.

Early on, climate scenarios were used as tools around which to create a standard set of scientific investigations; in 1987 a set of scenarios was generated using an early four-layer global climate model and used to assess a wide range of impacts for Australia (Pearman, 1988). This exercise resulted in the initiation of adaptation measures in southwest Western Australia responding to reduced rainfall because the climate model, even at that time, projected similar reductions long term (Power et al., 2005). Soon after the Intergovernmental Panel on Climate Change was instituted in 1988, scenarios had become an essential tool of climate change assessment: the first IPCC scenario families were being developed (Pepper and Intergovernmental Panel on Climate Change., 1992) and guidelines were being written for impacts and adaptation assessment (Carter et al., 1994). Guidance on the use of scenarios is provided by the Task Group on Data and Scenario Support for Impact and Climate Analysis (IPCC-TGICA, 2007) and is regularly updated in IPCC reports (Carter et al., 2001; Hulme and Mearns, 2001; Carter et al., 2007).

Each generation of IPCC emission scenarios has been underpinned by a storyline, the most detailed being the four storylines of the Special Report on Emission Scenarios (SRES (Nakicenovic and Swart, 2000). Altogether forty-two individual scenarios were quantified from these four storylines, although most assessments draw from the six marker scenarios. Scenarios were appropriate for exploring climate futures in the 1970s and 1980s because high scientific uncertainties did not allow forecasts to be made. Improvements in the science allow subjective probabilities to be attached to future climates, crossing the line between plausibility and likelihood. Even parts of the IPCC have been confused by this – Nakiçenovic and Swart (2000) were careful to state that the SRES scenarios were plausible, but Working Group I in the IPCC Third Assessment Report said they were equally plausible (IPCC, 2001). This oxymoron led to the perception amongst many that the scenarios were equally probable, creating confusion about their application (Goodess, 2000). This was despite clear and widespread instruction that they were not e.g., (Nakicenovic and Swart, 2000; Jenkins and Lowe, 2003). Any prior assumption as to how likelihoods are constructed is made by the researcher (Schneider, 2001) – the IPCC having given no specific advice on how to construct and apply likelihoods.

Due to the changing nature of climate information, CSIRO changed the title of its periodic release of climate scenarios for Australia to projections in 2001 (CSIRO, 2001) because they were moving towards prediction, albeit of low confidence. (Carter et al., 2007) produced a nomenclature of scenarios, projections and predictions to clarify the changing nature of climate information (Figure 1). For this reason, the nomenclature developed by (Borjeson et al., 2006), which nominates predictive scenarios as a scenario type is rejected here, because it crosses the line between plausibility and probability. Once a system is into prediction, it is no longer using scenarios.

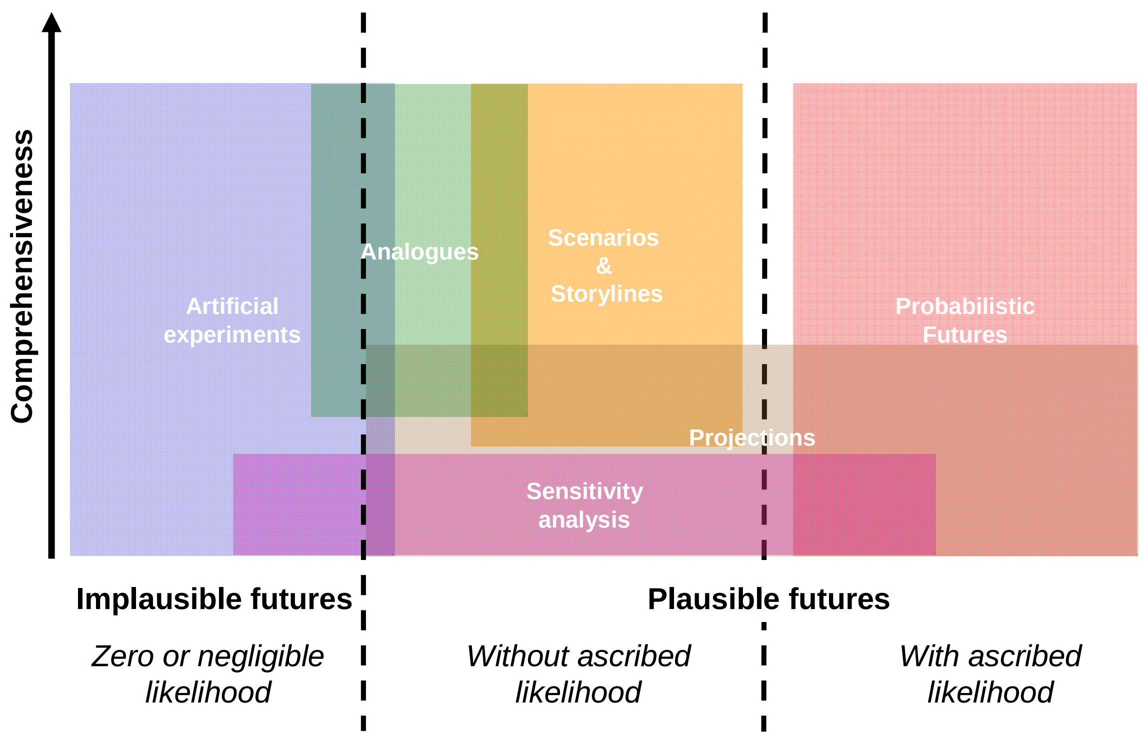

Figure 1. Characterisations of the future (Carter et al., 2007)

Although there is a continuing debate about the quantification of scenarios there are sound scientific reasons for wanting to quantify plausible outcomes without necessarily addressing their likelihood. Creating a consistent set of conditions for the testing and comparisons of a range of models, drivers of change and across different regions and sectors being the major reason e.g., (Moss et al., 2010). (Fontela, 2000) argues that combining modelling and scenario techniques to get the best out of all tools is a sensible approach to long-term planning. However, in doing this, it is necessary to be quite clear about what methods are being used and how they are being combined.

Scenario typologies

Many typologies of scenarios can be found in the literature. In resisting the urge to produce another, three (Borjeson et al., 2006; van Notten, 2006; Wilkinson and Eidinow, 2008) are described and adapted.

Van Notten (2006) describes a comprehensive typology of scenarios listing three major characteristics and ten minor characteristics. The three major characteristics are goals, design and content. This typology is not fixed; typologies tend to reflect the state of play at the time, become outdated as the field evolves and often fail to capture the full range of contemporary scenario development (van Notten, 2006). Van Notten's (2006) characteristics are useful but follow a descriptive taxonomy rather than functional approach. (Borjeson et al., 2006) review typologies referring in particular to different paradigms, distinguishing between different philosophical underpinnings. They settle on predictive, exploratory and normative scenarios as their main scenario types. The latter two are widespread definitions, and are used in the IPCC (Carter et al., 2001), but here the predictive scenario is rejected as a type.

van Notten (2006) states: *there are thus varying definitions of "scenario" but on one point there is consensus: it is not a prediction*. If the phrase "A scenario is not a prediction" is Googled it returns about 3,650 hits (October 2010). Borjeson et al. (2006) and Wilkinson and Eidinow (2008) both discuss scenarios with regard to prediction. Borjeson et al. (2006) justify predictive scenarios as a type because many practitioners use the term prediction in connection with scenarios. However, because one of the main reasons for using scenarios is to open up enquiry and choice rather than close it down, it seems counterproductive to encourage this perception. While people have a strong desire for prediction, the capacity to predict in complex systems is limited – hence the need for scenarios. If an outcome was simple to predict, then one would use a prediction.

Similarly, builders and users of scientific models often mistake scientific prediction for prediction of the future. Scientific prediction is based on a specific set of assumptions, so while the theory in a model may be correct, it may not be complete, especially in a system with various drivers and feedbacks. For example, the greenhouse gas emission SRES scenarios used by the IPCC cannot themselves predict future temperatures because they represent futures with no climate policy, whereas climate policy is already being implemented. Exploratory scenarios have the capacity to survey a range of plausible futures in forecasting mode, therefore predictive scenarios become redundant.

Many of the existing typologies are ex post, rather than focusing directly on the nature of the enquiry being made. *The scenarios seem to be regarded as products of research, rather than as tools designed to function in particular sorts of inquiries* (Wilkinson and Eidinow, 2008). This is not particularly useful for deciding which approach to take when selecting where and how to use scenarios with an assessment. For example, although the classifications of predictive-empirical, cultural-interpretative and critical-post-structuralist methods (Inayatullah, 1990), are relevant in understanding the history of scenario-use, they are not so useful in prospect.

The Wilkinson and Eidinow (2008) typology centres on problem-based, actor-based and reflexive interventionist multi-actor based scenarios. These definitions, designed to fit into the post-normal science framework of (Funtowicz and Ravetz, 1993), seem strained. Exploratory and normative definitions could easily substitute the problem-actor construct. However, the overall process of moving from a problem base, to its social setting to a reflexive-interventionist mode mirrors the decision-making process involved in assessing complex risks. The reflexive and iterative application of the risk management process, using a systems rather than linear approach, is preferable to the post-normal science construct. Wilkinson and Eidinow's (2008) typology can be adapted to that end.

Linking these typologies with approaches to impacts and adaptation research methods summarised by Carter et al. (2007), the major determinants of scenarios can be described as actor–subject, exploratory–normative, top-down–bottom-up (in terms of scale) and forward-looking–back-casting (or prescriptive-diagnostic). The latter can also be considered as a process-goal construct. While exploratory scenarios are prescriptive, normative scenarios can be run in both fore- and back-casting modes. Forward casting normative scenarios will concentrate on the initial state and process, for example a set of specific policies, whereas back-casting will define a normative state in the future; e.g., sustainability, then diagnose how to achieve that state over time given starting conditions and set of key drivers.

Wilkinson and Eidinow (2008) discuss scenario types with respect to wicked problems: issues embedded in the outcomes of complex system interactions. The typology they propose can be adapted to the decision-making context within the assessment of complex risks. They make two important points: modern practitioners will often borrow widely from the different scenario traditions so a fixed typology may be counterproductive, and rather than trying to forge a single world view through a scenario-building exercise, the aim is to describe a range of epistemic views in that one exercise.

Here I describe how scenarios may function in a risk management context. Both the epistemological and ontological aspects of scenarios need to be better grounded: in ontology – "what do we know?", epistemology – "what can we believe?"[1] and agency – "how can we act?".

Classifying risk

Tame and wicked risks

Risks can be classified as to whether they are tame, or are 'wicked system' risks. Tame risks are characterised by a widely agreed conceptual framing of a given risk. Values are bounded and there is

[1] This usage is based on Dancy, J. (1995) Problems of epistemology. In *The Oxford Companion to Philosophy* (ed. Honderich, T.). Oxford University Press, Oxford and New York, pp. 245-248., who defines epistemology the study of our rights to the beliefs we have. I take the view that risk perception has an epistemic origin in personal belief, where formal and informal understanding of knowledge may often come into conflict. Scenarios are excellent tools for exploring the intersection between these two areas of understanding.

an established process for calculating risk with the capacity to reconcile calculated and perceived risk.

Risks in complex situations are characterised by conflicts in how the risks are framed: this includes the metrics by which risk is measured and disagreements as to whether a given risk or the set of solutions proposed to solve that risk will cause the greatest harm. These risks are consistent with the range of characteristic associated with wicked systems (Rittel and Webber, 1973): the limits of a wicked system are difficult to constrain, it is multi-causal and has many interdependencies, addressing the problem will have unforeseen consequences, the issue is not stable, has no clear conclusion, is socially complex, is not the responsibility of one organisation at single scale, will involve changing behaviour and is beset by chronic policy failure (Australian Public Service Commission, 2007) and market failure (Stern and Treasury, 2007; Garnaut, 2008).

Tame risks with bounded values can be managed using a linear process of standard risk assessment. The ISO standard for risk (ISO, 2009) provides a generic assessment framework:

1. Establish the context: what do we need to take account of and what are our objectives?
2. Identify the risks: what might happen – how, when and why?
3. Analyse the risks: what will this mean for our objectives?
4. Evaluate the risks: which risks need treating and which are the priority for our attention?
5. Treat the risks: how best should we deal with them?

Two over-arching concepts are:

- Communicate and consult: who are our stakeholders, what are their objectives and how should they be involved?
- Monitor the risks: have the risks and controls changed?

Linear application will treat the framework as a continuous assessment process. In these settings, scenarios are useful but relatively simple: addressing gaps in knowledge in one or more of the five stages above, or facilitating communicating amongst collaborators (e.g., researchers and stakeholders).

A cognitive model of risk

The psychology of risk changes throughout the risk assessment process. Three important aspects of risk are idealised risk, calculated risk and perceived risk that link the conceptual, technical and believed aspects of risk. Idealised risk is the cognitive model of risk as it is framed during the scoping phase. Calculated risk is the scientific and technical aspect that aims to estimate the idealised risk as accurately as possible. Perceived risk is the rough estimate of risk by a member of the general public.

The heuristics of gain and loss, the diverse cultural mapping of attitudes to risk, different risk-averse and risk-seeking behaviours, rates of time preference and sense of personal identity all affect the perception of risk. It will also affect how an idealised risk is calculated according to a given paradigm, for example, those of Inayatullah (1990) listed earlier. This is relatively straightforward in simpler settings where the risk in question is bounded. However, in complex systems with competing risks, it can be problematic, especially where the researchers involved are not responding in a reflexive manner; i.e., they are framing risk in a particular way but are not aware of the competing frames involved in the calculation and perception of those risks.

The etymology of risk changes throughout the risk assessment process from a noun to a verb as does its meaning (Hamilton et al., 2007; Fillmore and Atkins, 1992). Many of the psychological and sociological aspects of risk perception also seem to hinge on this change. When a risk is identified and analysed, the exposed place, community or process is <u>at risk</u> because something of value is vulnerable to harm. Under risk evaluation and management, <u>to risk</u> seeks to gain advantage under uncertainty. This change marks a shift from a state of vulnerability to a process of risking for gain; however the more modern usage has been to emphasise the former at the expense of the latter (Füredi, 2002). For tame risks, the step in moving from what is <u>at risk</u>, to <u>take a risk</u> in terms of treatment is less problematic because the risk is more likely to be accepted in light of the benefits. However, the acceptance of a familiar risk, in the case of smoking for instance, may be counterproductive resulting in increased risk (Slovic et al., 2004). The change in the risk of loss to risk of gain also mirrors behavioural economics, where the weights given to the chance of loss are greater than those attached to the chance of gain e.g., (Tversky and Kahneman, 2000; Kahneman, 2003).

Some of the largest biases affecting the perception of risk come from the psychological effects of uncertainty and dread. Psychometric studies suggest that perceived risk can be three orders of magnitude different to calculated risk (Smil, 2008) and that uncertainty and dread are two major drivers of this difference (Weber, 2006). The difference between familiar and unfamiliar risks can also be interpreted in this light, where familiar risks are often more tolerated than more likely but less familiar risks. Culturally-driven perception of risk also means that perceived risk, including how risks calculated by experts are perceived by different stakeholder groups, can vary widely (Douglas and Wildavsky, 1982; Kahan et al., 2007).

The combination of climate, climate policy and political risk, and the change in heuristics from 'at risk of loss' to 'to risk for gain' lead the default linear model of risk into the risk trap, oscillating between extreme states of perception (Beck, 2000). This also describes the process involved in the social amplification of risk (Pidgeon et al., 2003).

For example, plausible climate scenarios show that serious risks threaten a farming activity between 2020 and 2060 through warming and drought[2]. The risk is uncertain in terms of both timing and magnitude, but considered likely if mitigation policy is ineffective. If these threats are realised, the viability of the farming system will require transformation from the current set of farming activities. Transformation is itself risky on a range of scales from personal self-interest through to system viability. The different elements involved in applying change will themselves compete in timing and importance. The present identity and livelihoods of those who have invested time, effort and finances in the current farming system are put at risk by the research findings – these individuals face that threat now, for an uncertain future. By making these risks visible, science can be perceived as putting stakeholders at risk. Within a community, competing risks can easily be amplified – some

[2] This example is generic. Although specific examples exist in the regional context relevant to the project (e.g., water reform), they are emotionally charged for many people.

individuals will be motivated to change, others sit on the fence and yet others are opposed. This opposition spreads to various institutions – those promoting change and those opposing change.

The role of scenarios will change throughout the process of implementing change. Initially, scenarios can be used to scope the key drivers then assess risk at the local level. In a farming community, environmental, social and economic risks all need to be considered. But to change that into action the focus need to shift from what and who, to how. The viability of the farming system and farmers' livelihoods becomes the central focus, and maintaining that viability under change, the aim of scenarios. This is highly normative and can be explored through both ends and means approaches. By focussing on the process of change these scenarios have been termed adaptation scenarios and are quite distinct from climate change scenarios.

Complex risks such as climate risks can therefore be separated into two parts. The first covers *what is at risk* – calculated risk incorporating a specific framing of events and values to be analysed; and the second covers *to take a risk* for gain. The second part accepts the conclusions of a calculated risk, but focuses on enabling social learning as part of managing the uncertainty associated with acting. Scenarios will play a key role in both parts.

This suggests three separate roles for scenarios within the risk assessment process: during the scoping, risk analysis and risk management phases. A fourth, drawn from Wilkinson and Eidinow (2008) can be used in complex system settings. The following sections describe each of these roles.

The use of scenarios in risk assessment

Scenarios for scoping risk

(Beer, 2006) describes the use of scenarios to scope risks. In this description, scenarios are applied in the tradition of global foresighting e.g., (Glenn and Gordon, 1997) and used to describe the context within which specific risks may occur. This framework includes both exploratory and normative scenarios asking the questions "what future do you think there will be?" given a specific set of underlying drivers and conditions, and "what kind of future would you like to see?" given a specific set of values and goals (Beer, 2006). Scenarios are thus used to escape defining risk solely on the basis of past experience.

In complex settings, scenarios can be used to identify a wide range of risks, rather than existing or obvious risks. Therefore, a problem-based scenario may not start with a single issue such as climate change, but aim to identify all the relevant problems. The act of scenario building opens up possibilities in a creative manner, both with what might happen and what can be done to prevent or promote those outcomes based on whether they are viewed as harmful or beneficial. Having carried out this task, the risks that merit further analysis can be assessed.

(Hay, 2006) recommends scoping risks to identify those that requite scenarios to be constructed for further analysis, so risk scoping can also be used for scenarios selection. (Jones and McInnes, 2004) describe the use of climate scenarios to scope a range of climate risks for four sectors in Victoria using climate change scenarios in a participatory manner, identifying key vulnerabilities and levels of tolerable risks for management purposes. The sectors covered were water, agriculture, coasts and biodiversity. One lesson from this exercise was that considerable expertise in the operation of a system is required, involving a wide range of stakeholders. Within the Australian context, climate scenarios are now being used to scope risks in a great many situations, such as local government areas, catchments and regions, so has become a common activity.

Most climate change scenarios delivered at this stage are top-down, usually global scenarios taken and downscaled to local level. The Climate Change Impacts and Risk Management Guide for Business and Government (AGO, 2006) provides guidance for impacts which is best used in the scoping phase of a risk assessment. Global scenarios used are the SRES emissions scenarios (Nakicenovic and Swart, 2000) with regional climate provided by (CSIRO and BoM, 2007).

Purpose: to investigate a system (activity, location or group of people) in order to determine which risks require further attention.

Scenarios for risk analysis

The risk analytic stage assesses what is at risk, estimating likelihood and preparing for the ranking and evaluation of risks. It can be a direct continuation of risk scoping, start afresh or be the first step in an assessment if the scoping phase has not been required.

Climate-related risks can be assessed using a range of metrics set by policy and the literature, or through participatory methods developed with stakeholders (Pittock and Jones, 2000; Smit and Wandel, 2006). If metrics are institutionalised and widely accepted (e.g., the 1:100 year flood), they can be readily accepted, but many risks are uncertain and have no clear thresholds identified as acceptable, unacceptable or disastrous. These would need to be surveyed within the context of the assessment. Other factors to be addressed may include the interaction of multiple drivers, sustainable development pathways and human and environmental security. The latter is especially important because most serious vulnerabilities are not due to climate alone, but are the combination of climate and other drivers of change (O'Brien et al., 2004).

Where uncertainty is significant, scenarios can achieve what scientific models perhaps cannot. For example IPCC Working Group I in the Fourth Assessment Report, considered there was insufficient confidence in ice sheet models for researchers to quantify ice sheet melt for projections of sea level rise (IPCC, 2007). However, large-scale melting of ice sheets poses a significant long-term risk. Because omission has hampered risk assessments (Rahmstorf, 2010), researchers have returned to the Third Assessment Report or used simple sea level rise models (Church et al., 2008; Rahmstorf, 2010). Scenarios are ideal for this type of task and can be used to analyse and evaluate risk where there is sufficient confidence that an event is plausible but insufficient confidence in the scientific ability to quantify that risk. Risky outcomes can be assessed using a range of sources within a scenario setting. Both prescriptive and diagnostic assessments can be used (i.e., event and outcome based approaches) to explore vulnerability to climate change and broader social vulnerability.

The precision demanded by science is not as necessary for understanding and communicating risk, nor is it required for making policy. If evidence-based policy is the benchmark, then evidence can come from a scenario-driven risk assessment, as long as the process is transparent. This view means there is less pressure to take science-driven scenarios such as the IPCC emission scenarios and downscale them to the local level in a science-driven assessment. Many local processes will be independent of global trends, so there is a great deal of freedom in generating local story-lines and blending them with global scenarios.

Purpose: to investigate a specific set of risks within a system (activity, location or group of people) in order to determine whether they need to be managed. This stage may go through to ranking risks and scoping adaptation options.

Scenarios for risk management

Risk management concentrates on decision-making under uncertainty, in the context of this paper, specifically adaptation. This role is strongly normative. The focus is on decision-making under uncertainty and is dominated by bottom-up approaches focussing on the system in question. For adaptation, futures through exploratory and normative methods can be surveyed.

The heuristics with regard to risk also changes from analysis to management, whereas the emphasis is on benefit rather than loss. If an assessment has identified vulnerabilities and they are accepted by stakeholders, then the position at the end of the risk analytic stage is one of loss. Scenarios in this context then explore the potential for gain from that position of loss.

The main reason for separating risk analysis and management is the change in how risk is perceived across the loss-gain interface as we move from what is at risk, towards opportunity. In complex settings, this is where the social amplification of risk occurs (which also includes attenuation), often because loss associated with the risk being analysed and the potential loss associated with management options come into conflict.

The purpose of adaptation scenarios is to explore a prospective portfolio of adaptation options by contrasting them in different value settings, become familiar with potential solutions which will reduce the unfamiliarity heuristic and set in place a strategy of learning by doing.

These solution-based strategies are being pursued by several research communities under the banner of adaptation scenarios (Stuczyiński et al., 2000; Easterling et al., 2003; Droogers and Aerts, 2005; Hallegatte et al., 2007), resilience planning such as being developed and applied by the Resilience Alliance (Gallopin, 2002; Walker et al., 2002; Moore and Huntington, 2008) and community development (VanWynsberghe et al., 2003).

Purpose: to explore potential solutions to a given set of risks, develop a portfolio of management actions and get moving.

Reflexive scenarios

Reflexive interventionist multi-actor based scenarios are the most sophisticated of these scenarios, involving all three of the previous scenario constructs. They are most useful in complex system settings, where both the risks and solutions are uncertain, 'surprises' can be anticipated and there are confounding processes and values (Wilkinson and Eidinow, 2008).

Reflexive scenarios involve a systems approach where an adaptation strategy is the main aim. Reflexivity applies where actors within a system observe that system and their response to it over time, monitoring anticipated and emerging risks and their own reaction to those ongoing changes. This is the most complex and least practised set of scenarios and marks the difference between periodic strategic planning, where a plan is devised then rolled out until the next planning phase, and adaptive management, which has the capacity for large changes in response to changing circumstances in between planning phases. For example, a region may go through the process of scoping and analysing risks before deciding on a portfolio of adaptation options. However, in situations where normative goals are unclear – "I'm not sure what I want, but a) I know what I don't want and b) I will know it when I see it" – idealised risks, the concept of what is at risk – may change. A landscape may change from a production landscape to an amenity landscape, so that while one normative goal: sustainable livelihoods, may not change, another: maintenance of agricultural production systems, may change. The emphasis on viable jobs remains but the pattern of employment changes. In this case scenarios would be ongoing, having a long-term institutional role for an organisation, region, or sector as was the case with the Shell scenarios.

Such scenarios contain both exploratory and normative elements, applying both prescriptive and diagnostic methods. They so not seek a single consensus view but aim to accommodate a range of world views. Different actors become more aware of their own and other attitudes to the specific risks in question and how they use formal and informal knowledge in decision-making.

Purpose: to explore management options to a given set of risks in a reflexive manner by creating and maintaining scenarios in a 'live' setting. Reflexive behaviour involves constructing scenarios that scope, assess risk and risk management options. Ongoing management monitors the behaviour of the system in question, learning from both success and failure, monitoring existing and emerging risks and periodic revisiting of the scenarios to update them. It is likely that a range of scenario-building strategies will be used, rather a single scenario type.

Conclusions

Current state of the art

Scenarios in the area of climate and global change assessment are dominated by exploratory, top-down scenarios in forecasting mode. However, the research community is making a serious effort to develop participatory scenarios that cross the boundaries between knowledge and action and are salient, credible and legitimate (after (Cash et al., 2003). One of the key aims of using participatory approaches to scenario building is to facilitate social learning and to use knowledge to achieve action. However, the theoretical basis for this is not well developed, despite a deal of empirical evidence.

(Shaw et al., 2009) describe a three-step study in British Colombia that addressed the boundary between knowledge and action using images applied within a participatory approach. A set of global scenarios was developed from the IPCC SRES (Nakicenovic and Swart, 2000), Millennium Ecosystem Assessment (Carpenter et al., 2005)and Global Scenarios Group (Raskin et al., 2002). These harmonised scenarios were downscaled to the region and participatory vulnerability assessment c.f. (Smit and Wandel, 2006) undertaken with stakeholders. A set of localised narratives was then developed. Step three visualised those narratives using iconic local images. Guidelines for the ethical use of imagery were applied, with systemic perspectives providing the knowledge base and visual imagery affecting a response. The overall approach was an exploratory framework. Further research will explore the role of visualisation in translating knowledge into action.

Scenarios are also widely being used in community-based adaptation, where the nexus between development, climate risk and natural disaster is being explored to facilitate community development (van Aalst et al., 2008). In such situations, knowledge of the contributing risks does not need to be all that precise. The common elements involve community participation, social vulnerability/adaptive capacity and development pathways (O'Brien et al., 2008). Participatory methods are used to assess hazards, vulnerabilities and capacities in support of community-based risk reduction (van Aalst et al., 2008). Plans are then developed to enhance and utilise those capacities.

The Systems Approach to Regional Climate Change Adaptation Strategies in Metropolises project assessed the vulnerability (Preston et al., 2008) and adaptive capacity (Smith et al., 2008a) of a coastal region covering fifteen local government areas in Sydney. The study applied projections from a range of climate scenarios to develop maps of vulnerability, then focussed on adaptive capacity. Therefore both a problem-based and a solution-based methodology were applied using a systems approach. Based on the synthesis of a series of workshops (Smith et al., 2008b) using influence mapping to follow pathways of vulnerability originating in climate change, the major issues centred on core business of local government; such as communities, infrastructure and planning and decision-making. Opportunities for adaptation were identified in the areas of community, planning and development, with knowledge, education and policy viewed as important but less significant. This recognises the overwhelmingly social face of adaptation – policies are less important than developing the capacities of communities to implement those policies. The project recommended a set of collaborative actions that local government could introduce to develop and promote change (Smith et al., 2008a). Although not a scenario-driven study, the systems approach applied involved a high degree of reflexivity, the collaborative nature of the process helped develop an institutional capacity amongst the Sydney Coastal Council Group to recognise and manage ongoing change.

The development of ongoing collaborations of this type, where institutions involved in governance and the community become the drivers of adaptation have the potential to develop and maintain reflexive scenarios as tools for fore-sighting solutions, tracking progress and monitoring ongoing and emerging risk.

Summary

This paper addresses scenarios in a range of settings designed to manage risk, ranging from simple to complex. The value of participatory approaches where scenarios are developed in a collaborative mode to facilitate decision-making is taken as a given. The main conclusion is that the use of scenarios changes according to the complexity of the system and/or issues being faced. Risks can be classified as to whether they are tame or complex. Scenarios have three main roles within the risk assessment process: in scoping risk, risk analysis and evaluation, and risk management. These can be linked to idealised risk, calculated risk and perceived risk.

For tame problems, risk assessment methods can be applied as a continuous process where risk management options flow on logically from analysis and evaluation. The main application of accompanying scenarios is as a communication device. Major roles include gaining a shared view of the problem from a number of different perspectives (e.g., researcher, planner, operator, policymaker) that involves understanding different conceptual approaches to the issue, different terminology and different metrics (e.g., policymakers will be motivated by policy completion and uptake, operators by profit and livelihood).

For complex risks, what is at risk and the perceived risks in managing those risks compete with other according to different world views. This brings into contrast the change in cognitive approach to risk in calculating what is at risk, compared to taking a risk to manage those calculated risks (Figure 2). The heuristics of loss and gain, different levels of risk tolerance and time preference, and perceived risks all contribute to messy situations where scenarios become an important tool in working to accommodate these differing views.

Research examples are beginning to demonstrate a switch in stakeholder thinking from 'at risk' to 'to risk'. This occurs when risks are understood and accepted but the solutions to managing those risks remain unclear. Procedures for developing adaptation scenarios and similar approaches targeting resilience and adaptive capacity need to be improved. Methods that assume social learning can proceed from a better understanding of the risks have no guarantee of working in complex situations because of the many different perceptions of risk that abound.

In these situations, crossing the boundary from research to action requires re-orienting the approach to the way that knowledge is used in decision-making. There is a cognitive divide between distinguishing what is at risk where risk is a noun, to taking a risk for gain, where risk is a verb. The aim of the first process is to provide knowledge and the second, the capacity to act. This has significant implications for scenario building and use.

Stage of assessment	Research question
Scoping	What is the domain of the area of interest, who will be involved and what methods will be applied?
Identification	What risks do we need to assess?
Analysis	What is their likelihood and potential impact?
Evaluation	Which options best manage those risks?
Management	How do we implement adaptation actions?

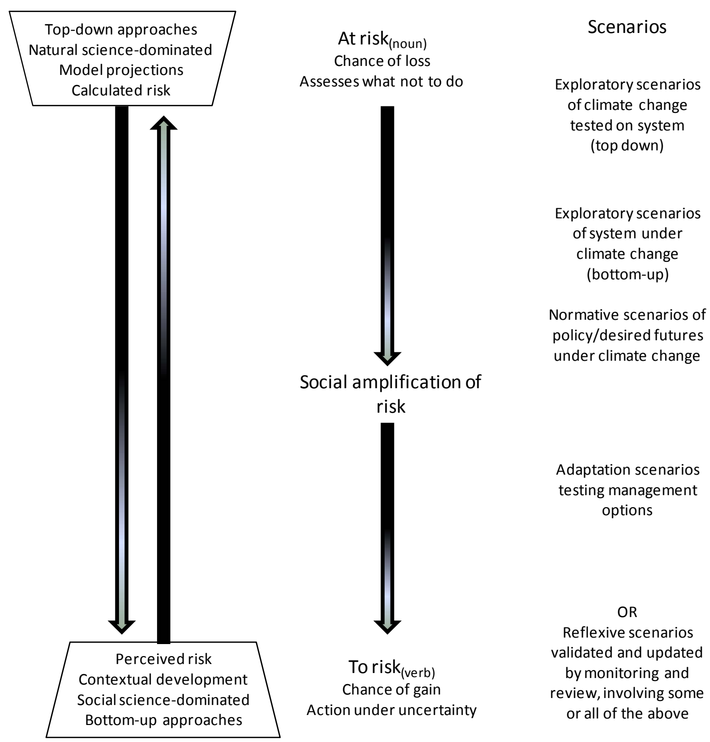

Figure 2. Schematic of the risk assessment process, interplay of research methodologies, cognitive model of risk and scenario application for managing risk within complex environments.

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