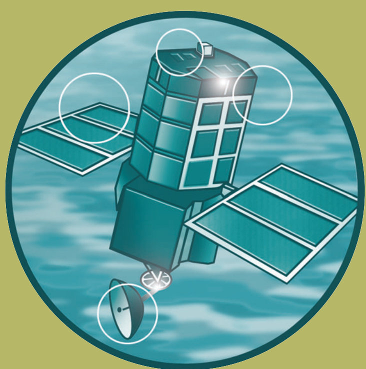
Joint Defra/EA Flood and Coastal Erosion
Risk Management R&D Programme

Developing an evidence base for appraisal guidance
Task C Annex and appendices

R&D Project Record F2019/PR6



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Joint Defra/EA Flood and Coastal Erosion Risk Management R&D Programme

Developing an Evidence Base for Improving Appraisal Guidance

R&D Project Record FD2019/PR6 (Task C)

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Risk & Policy Analysts Limited
Royal Haskoning Limited

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Research contractor: Risk & Policy Analysts Ltd and Royal Haskoning (UK) Ltd

Defra project officer: Karl Hardy

Publishing organisation
Department for Environment, Food and Rural Affairs
Flood Management Division,
Ergon House,
Horseferry Road
London SW1P 2AL

Tel: 020 7238 3000 Fax: 020 7238 6187

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Executive summary

Task C better reflecting future changes and promoting adaptability

The aim of Task C is to identify, based on a review of literature and the results of the previous tasks, how scenarios have developed and have been used over time in a variety of applications. The overall outcome of Task C is to provide a discussion on the use of scenarios including examples of their application and the benefits and pitfalls of using them. This includes the need to consider how a scenario-based approach could encourage integration and more sustainable solutions for flood and coastal erosion risk management. The observations/conclusions then feed into the Final Report, with the aim of informing the development of an updated suite of appraisal guidance.

Conclusions

There is no doubt that scenario analysis can provide valuable information to decision makers on potential impacts from future changes. The potential changes can include those associated with climate change, land use, social behaviour, etc. The one thing all these potential changes have in common is that there is uncertainty as to the timing and degree of impacts.

The present guidance does not cover the use of scenario analysis in detail and especially in how this can be used to improve decision making. Scoping of the use of scenario analysis currently used in a number of different applications has also not provided any detailed guidance on how the results feed into the decision process.

There is a wide range of potential uncertainties when dealing with flood and coastal erosion risk management from both drivers and receptors while different levels of analysis have been used from the simple increase in run-off as a sensitivity analysis to the more complex Foresight scenarios.

The review of PARs, results of consultation and other literature point to the need for guidance that is easy to understand and be implemented by practitioners and therefore has to be fit for purpose. This extends beyond sensitivity analysis to scenario analysis to explore the effects of potential changes to drivers and receptors. The challenge will be to provide this guidance in a way that can be used effectively and efficiently and that will affect (and improve) the way decisions are made.

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1. Introduction

1.1 Background to the study

FCDPAG 1 (MAFF 2001) defines Project Appraisal as: "the process of identifying and then evaluating options in order to select the one that most closely satisfies the defined project objectives. In the context of flood and coastal defence strategy and scheme appraisals these objectives include:

- reducing the risks to people and to the developed and natural environment from flooding and coastal erosion;
- identifying a solution that is technically sound and most fit for purpose;
- being environmentally acceptable and sustainable; and
- ensuring best value for money from a national perspective."

The approach to project appraisal in flood and coastal erosion risk management is based on this definition. However, the definition appears to focus on a comparison of defined options and does not emphasise the role of developing options through learning and feedback from the appraisal process.

Making Space for Water (MSfW) clearly states the Government's aim for flood and coastal risk management as: "to manage the risks from flooding and coastal erosion by employing an integrated portfolio of approaches which reflect both national and local priorities, so as:

- to reduce the threat to people and their property; and
- to deliver the greatest environmental, social and economic benefit, consistent with the Government's sustainable development principles."

It is clear that appraisals are therefore central to achieving and delivering the Government's aim. This study, through reviewing and analysing existing appraisals and potential improvements, will provide a better understanding of the guidance that supports the appraisal process, how it can be improved to contribute to better decisions and be cost effective, in the quest to reduce risk and be consistent with sustainable development principles.
The study will need to be informed by other projects being carried out under the MSfW delivery programme such as "Identifying the barriers and incentive to the delivery of better environmental and social outcomes", R&D projects such as "Evaluating a Multi-Criteria Analysis Methodology for Application to Flood Management and Coastal Defence Appraisal" and "Integrating Cost-benefit Analysis and Multi-Criteria Analysis of Flood and Coastal Defence Projects" (the Sugden Approach), and Foresight Scenarios.

1.2 Aims and objectives of the study

The aim of the study as set out in the project specification is to:

- explore the potential for improvements to the existing project appraisal guidance (Defra 1999-2001) to reflect the findings of the Foresight Study

(OST 2004) and the direction of travel identified in the Government's first response to the Making Space for Water (MSfW) consultation (Defra 2005).

The objective of the project is to:

- develop evidence that will allow Defra and the operating authorities to improve guidance and thus assist practitioners make better decisions.

1.3 Organisation of this report

This report comprises Task C: *better reflecting future changes and promoting adaptability*.

- Section 2 sets out the aims, objectives and approach of Task C;
- Section 3 gives the theory of scenario based planning;
- Section 4 presents the present guidance for scenario analysis for FCERM project appraisal;
- Section 5 describes scenarios developed for other fields;
- Section 6 gives examples of scenario analysis in practice;
- Section 7 describes the present guidance and practice on climate change;
- Conclusions are in Section 8; and
- References are given in Section 9.

1.4 Structure of the draft final report

This report forms one of five Task Reports which provide a summary of the results of each Task to inform the Final Report. Figure 1.1, overleaf, shows how these reports feed into the Final Report and draw on the evidence collected and reviewed during the study.

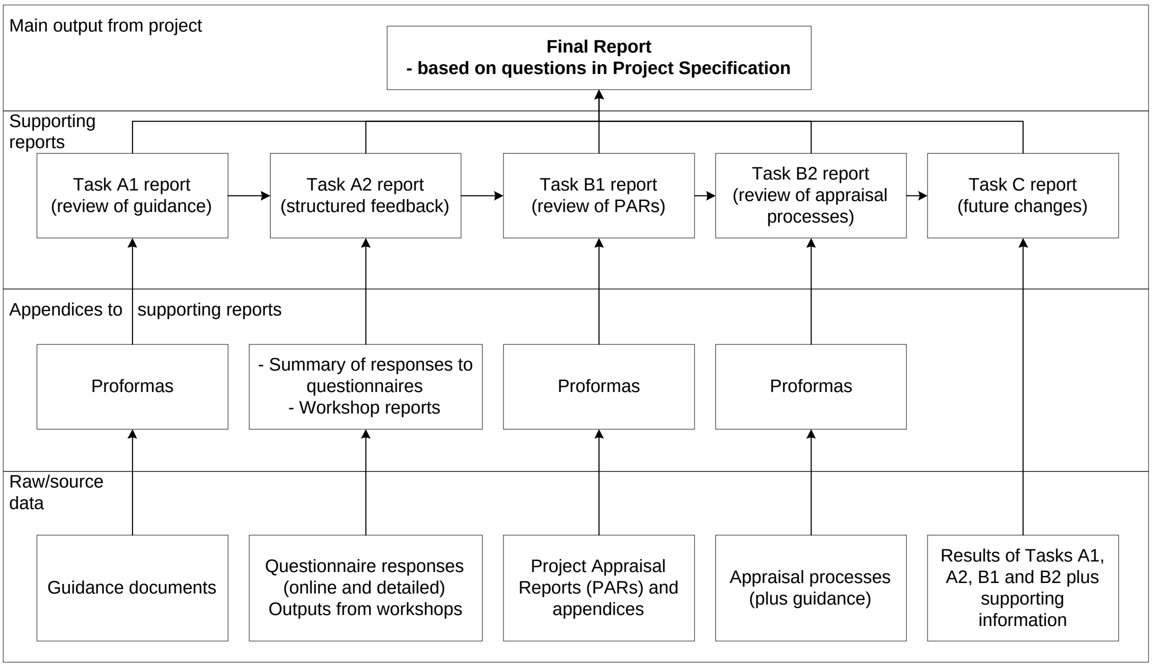

Figure 1.1 Structure of the outputs forming the Final Report

2. Aims, objectives and approach of Task C

2.1 Aims and objectives

The aim of Task C is to identify, based on a review of literature and the results of the previous tasks, how scenarios have developed and have been used over time in a variety of applications. The overall outcome of Task C is to provide a discussion on the use of scenarios including examples of their application and the benefits and pitfalls of using them. This includes the need to consider how a scenario-based approach could encourage integration and more sustainable solutions for flood and coastal erosion risk management. The observations/conclusions then feed into the Final Report, with the aim of informing the development of an updated suite of appraisal guidance.

2.2 Approach

Task C has involved extensive literature review covering the academic and practical literature surrounding scenario analysis (plus alternative titles such as scenario technique, scenario-based planning, scenario building and scenario approaches). The aims of the additional review work were;

- to identify definitions for scenarios and scenario analysis;
- to assess how scenario analysis should work; and
- to review projects and approaches where scenario analysis has been applied in order to benefit from lessons learned.

Task C has also taken information from Tasks A1, A2, B1 and B2 and additional information from a variety of sources. This has helped to ensure that there is a learning process throughout the project, where results from one Task inform another, with the overall goal being to meet the objectives of Task C and the overall project. Task C brings together evidence of how scenarios could be used within appraisals to address a variety of future changes that are in themselves uncertain.

3. The theory of scenario-based planning

3.1 Why might scenarios be necessary?

Management approaches associated with engineering projects tend to be characterised by a control paradigm. This involves the assumptions that (Pahl - Wostl 2004):

- a system can exist in a finite set of states and each state can be uniquely characterised by observation;
- based on this characterisation, a unique set of control measures can be identified to move the system from one state to another state;
- uncertainties in the state transition functions can be quantified by probabilities; and
- risks are quantified by multiplying the probability of an event with the magnitude of the expected damage.

This results in the construction of technical systems that can be controlled. However, human-technology-environment systems are more appropriately described as complex systems which require different paradigms. Complex systems are characterised by self-organisation, adaptation, heterogeneity across scales and distributed control. The system attempts to escape external pressures by adaptation in changing its internal structure and is itself in constant change (Pahl-Wostl 2004).

Humans typically tend to reduce the complexity and dimensions of a problem with which they are confronted with a problem to be tackled (Sterman, 2000; Vennix, 1996 in Pahl-Wostl 2004). The result is that a problem situation is often compressed into a description of a well-defined problem with simple cause-effect relationships (Pahl-Wostl 2004). This can give the perception that the solution is easy to identify, but once implemented, it becomes clear that the 'solution' has resulted in unexpected impacts or caused new problems that now need to be addressed.

The approach currently used in FCERM does not encourage analysis of future changes, with potential future impacts such as development being excluded from the appraisal. Making Space for Water also does not emphasise the potential role for scenario analysis in future appraisals, mentioning scenarios only in relation to the Foresight Future Flooding report.

3.2 Definitions

The literature (both academic and practitioner) provides a wide range of different possible definitions for scenarios and scenario analysis/planning/ building (etc.). There is no consensus as to the 'correct' definition of either term, although many of the definitions do converge to give a similar meaning. Table 3.1 summarises definitions of scenarios and scenario analysis. A wide range of sources has been used to generate the definition list, some of which may be considered more credible than others.

Table 3.1 Definitions of scenarios and scenario analysis

Scenarios	Scenario analysis
Scenarios represent a set of stories built around carefully constructed plots (Mietzner & Reger 2004).	Scenario planning does not pretend that we can predict the future. Instead it builds on existing knowledge to develop several plausible future scenarios. These can be used to construct robust strategies – that will play out well in several possible futures (ManyWorlds Inc 2001)
A scenario is a description of a future situation and the course of events, which allows one to move forward from the original situation to the future (Godet & Roubelat 1996 in Mietzner & Reger 2004)	Scenario planning…helps us understand the uncertainties that lie before us, and what they might mean. It helps us rehearse our response to those possible futures. And it helps us spot them as they begin to unfold' (Wilkinson 1996 in Mietzner & Reger 2004)
Scenarios are a narrative description of a possible state of affairs or development over time. Scenarios generally are based on quantitative expert information, but may include qualitative information as well (Warfield, 1996 in Mietzner & Reger 2004).	Scenario planning can be regarded as a tool for improving decision making against a background of possible future environments. It is an internally consistent account of how the …environment...might develop over time (ETTE 2002 in Mietzner & Reger 2004)
Scenarios can be used to obtain a number of different ends; they are internally coherent pictures of possible futures. They can dramatise trends and alternatives, explore the impacts and implications of decisions, choices, policies, etc., and provide insights into cause-and-effect sequences (Slaughter 2000 in Mietzner & Reger 2004)	Scenario technique is no uniform methodology. A multitude of different approaches, methods and tools exist, so that each scenario study is characterised by an individual way of doing it (Winterscheid 2006).
A scenario is a quantitative or qualitative picture of a given organisation or group, developed within the framework of a set of specified assumptions. This 'picture' can be developed in many different ways, by modelling, simulation or a variety of less quantitative techniques (MacNulty *et al.* 1977 in DG for Security Policy at the Austrian Military of Defence 2004) .	Scenario generation is similar to systems analysis and is also referred to as a process of 'qualitative causal thinking' (van der Heijden, 1996 in Winterscheid 2006).
Scenarios are coherent, credible stories about alternative futures. Because they involve using multiple perspectives to explore problems, scenarios can help create shared understandings of possible developments (Davis 2002 in DG for Security Policy at the Austrian Military of Defence 2004).	Scenario analysis offers a means of exploring a variety of long-range alternatives. Scenarios include images of the future, snapshots of the major features of interest at various points in time, and an account of the flow of events leading to such future conditions (GSG 2002).
A scenario depicts a possible future situation and beyond that it includes a description of the developments which have led to that particular future (Gausemeier *et al.* 1996 in Winterscheid 2006)	Scenario analysis is a process of analysing possible future events by considering alternative possible outcomes (scenarios). The analysis is designed to allow improved decision-making by allowing more complete consideration of outcomes and their implications (Wikipedia).

Table 3.1 Definitions of scenarios and scenario analysis

Scenarios	Scenario analysis
Scenarios deal with both the world of fact and the world of perceptions (Schwartz 1996 in Winterscheid 2006). Scenarios operate in the area of structural uncertainty and explicitly assume the existence of irreducible uncertainty (van der Heijden 1996 in from Winterscheid 2006). A scenario is a story that describes a possible future. It identifies some significant events, the main actors and their motivations and it conveys how the world functions (Shell International 2003).	The purpose of scenario planning is to help managers change their subjective view of reality, to match it more closely with actual reality and possible futures. The end result is not an accurate picture of tomorrow but better decisions about possible futures (Mietzner & Reger 2004).

Perhaps not surprisingly given the number of different definitions, of which Table 4.1 gives an indication, Mason (1994 in Bradfield 2004) states that the term scenario has become as ill-defined as the term strategy while Mietzner & Reger (2004) identify that the term scenario describes a fuzzy concept that is used and misused and, in practice, scenarios often merely describe particular sets of events or variables. This is also confirmed by our research.

Consolidated definitions, drawing on the range of definitions provided in Table 3.1 could be:

‘A scenario is a possible future situation and includes a description of the developments that have led to that particular future.’

‘Scenario analysis is a tool for improving decision making against a background of possible future environments. It helps us rehearse our response to those possible futures.’

3.3 The history and purpose of scenario analysis

3.3.1 The history of scenario analysis

Planning for the future (futures research) began in the 1940s and was linked to security and strategic analysis. The concept of scenario planning first emerged after World War II and was used as a method for military planning by the US Air Force. One of the leading protagonists was Herman Kahn who, having left the Air Force in the 1960s, refined scenarios as a tool for business prognostication (Mietzner & Reger 2004).

It was in the 1970s, through the work of Pierre Wack for Royal Dutch/Shell, that the potential of scenarios was first realised. An oil price shock in 1973 led to a major unexpected crisis in the international economic system. None of the major oil companies, with the exception of Shell, was prepared for the change. The company's management responded quickly and in the following years, Shell moved from being one of the weaker of the seven large oil companies that existed at the time to second in size and number one for profitability (Mietzner & Reger 2004).

By the 1980s, scenarios were being used as a tool that could be used as a form of sensitivity analysis. In the 1990s, the focus for scenarios shifted to find ways of changing mindsets so that managers can anticipate futures and prepare for them (Ringland 2002 in Winterscheid 2006). Ringland (2002 in Winterscheid, 2006) sees the future of scenarios being in knowledge management and as a thinking tool to provide a shared environment for the identification and discussion of assumptions.

3.3.2 The purpose of scenario analysis

As with the definitions of scenarios and scenario analysis, the purpose of the approach also varies widely according to the source or study. However, there are again some elements that are common to all.

Mietzner & Reger (2004) include three different potential purposes for scenario analysis from three different authors:

- Ratcliffe (2002 in Mietzner & Reger 2004) identifies that the main characteristics of scenarios are to:
  - present alternative images instead of extrapolating trends from the present;
  - embrace qualitative perspectives as well as quantitative data;
  - allow for sharp discontinuities as well as quantitative data;
  - allow for sharp discontinuities to be evaluated;
  - require decision-makers to question their basic assumptions; and
  - create a learning organisation possessing a common vocabulary and an effective basis for communicating complex, sometimes paradoxical, conditions/options.

- Fahey & Randall (1998 in Mietzner & Reger 2004) suggest that the purpose of scenario building is to:
  - augment understanding by helping to see what possible futures might look like, how they might come about and why this might happen;
  - produce new decisions by forcing fresh considerations to surface;
  - reframe existing decisions by providing a new context for decisions; and
  - identify contingent decisions by exploring what an organisation might do if certain situations arise.

- Nelson & Wagner (2000 in Mietzner & Reger 2004) suggest scenarios should aim to:
  - anticipate future threats and opportunities;
  - project multiple forecasts based on optimistic and pessimistic projections of past events;
  - foster strategic thinking and learning;
  - facilitate the art of strategic conversation;

- envision a future state;
- challenge or dispel assumptions about the 'official' future;
- create a rallying point;
- provide leadership for new initiatives or direction;
- create opportunities for decision-making;
- create frameworks for a shared vision of the future to influence organisational and individual behaviour; and
- create an internal or external communication channel that transcends organisational boundaries, time and space.

These various descriptions highlight that there are different approaches to performing scenarios and different ways of applying scenario analysis. However, they also identify that some aspects are similar to provide a consolidated list of the purposes of scenario analysis as (based on Mietzner & Reger 2004):

- clarification of the decisions to be made;
- rigorous challenge to the mental maps that shape people's perceptions;
- identification and collation of information from various sources;
- identification of the driving forces, predetermined elements and critical uncertainties;
- composition of three or four scenarios, each representing a plausible alternative; and
- identification of the key events or turning points that would channel the future towards one scenario rather than another.

It is only likely to be possible to generate a limited number of scenarios in detail, otherwise the process becomes unmanageable. The core question that needs to be answered when applying scenario analysis is: how can an approach be developed that will produce a manageable number of scenarios, in a logical manner, that best captures the dynamics of the situation and communicates the point effectively. Wilson (1998 in Mietzner & Reger 2004) states that the golden rule in deciding the number of scenarios is no less than two and no more than four. He suggests five criteria for selecting scenarios:

- plausibility: the selected scenarios have to be capable of happening;
- differentiation: they should be structurally different and not simple variations on the same theme;
- consistency: the combination of logics in a scenario has to ensure that there is no built-in internal inconsistency that would undermine its credibility;
- decision-making utility: each scenario should contribute specific insights into the future that help make the decision identified in step one; and
- challenge: the scenarios should challenge the organisation's conventional wisdom about the future.

It is essential to ensure that every scenario in the exercise is plausible, i.e. is logically self-consistent in the sense that each proposed event follows on from those that come before. Some stakeholders may regard certain scenarios as exceedingly unlikely and undesirable, but it should not be possible to prove any scenario impossible (Lempert *et al.* 2004).

3.4 Methods for taking account of future events in decision-making

3.4.1 Techniques and approaches

There is a range of different methods and approaches that can be used to take account of potential future events in decision-making, which include scenario analysis but also encompass other techniques such as extrapolation of trends, modelling and group consensus. These techniques can be categorised into the following five groups of techniques available to help understand, predict or prepare for the future (based on ManyWorlds 2001):

1. Emerging Pattern Monitors (EPM): scenario planning fits into this category, along with scanning, monitoring, tracking and simulations (including Monte Carlo models). EPM techniques assume that the future is not easily predictable, that it arises from the interaction of numerous forces and that single-track forecasts do not fit the dynamic reality of the environment's development. The strategic planning process must remain highly flexible since the future will continually alter, being buffeted by unexpected events and interactions of forces.

   Scanning, monitoring and tracking can be used in isolation and can provide inputs into the scenario planning process. Scanning aims to identify events or trends of any kind that may impact on plans or strategies; it provides the raw material for the driving forces of scenario planning. Monitoring involves following events or trends identified by scanning to determine whether trends are waxing or waning while tracking focuses more tightly on a particular area of development. Both are crucial parts in the implementation of scenario planning.

   Simulation attempts to formalise numerous forces shaping the future, assigning them probabilities. It offers an apparently rigorous approach to determining the shape of the future. However, they are sensitive to the assumptions built in and may be best used as a way of generating scenarios. The appearance of mathematical rigour in simulation is a dangerous illusion.

2. Extrapolators: extrapolators see the future as a logical, well-ordered extension of the past. It includes trend analysis and numerous techniques linked to changes in specific driving forces (e.g. technological, economic). It differs from scenario planning in that it produces a single extrapolated forecast.

3. Cyclical analysis: this is based on the belief that fundamental human drives combined with irresistible feedback mechanisms means the future will repeat identifiable cycles and patterns from the past. There are four types of cyclical analysis and can produce several possible future rather than a single forecast.

4. Goal analysis: this includes a broad collection of techniques which generally agree that future outcomes will be shaped by the actions of various agents (individuals or organisations). Therefore, it is assumed that we can best see ahead by examining the goals of these active agents, especially those capable of creating or sustaining trends. Goal analysis yields information about trends and driving forces, so can supply raw information for development in scenario planning.

5. Intuitive Convergers: this category includes Delphi surveys and does not believe that the future can be projected by any 'rational' or directed approach. The future is assumed to emerge from a complex and ever-shifting convergence of powerful trends, individual actions and happenstance Therefore, the best way to grasp the future is to gather information broadly the allow unconscious or intuitive information processing to yield actionable insights. Each technique uses a specific method of networking the information gathering and intuitive processing of groups of people. The result may converge on one likely future or it may highlight important developments or reveal basic differences in views, some of which have not previously received sufficient attention. Some of the techniques can play an important role in scenario planning by adding depth to the early scenario preparation process.

The various techniques can be further characterised by an additional five-way typology, yielding more information about the relative nature and use of scenario planning compared with other methods (ManyWorlds 2001):

1. directed versus emergent; directed techniques encompass what is usually (but unhelpfully) terms 'rational' and look at one or two trends or forces and let those drive forecasts. They work best in narrowly circumscribed situations where external factors are unlikely to disrupt salient trends. Emergent approaches can be highly structured and may include directed elements within a wider context. Emergence occurs where product or process functions are combined and recombined to uncover new opportunities.

2. narrow versus broad scope: scenario planning, when done well, has broad scope. The final output may be a set of scenarios that focus narrowly on a specific decision or strategy, but the process that crystallised scenarios drew on far flung trends and facts. Other EPM methods can have broad scope, especially scanning, while tracking will be narrow in scope. Extrapolation typically has narrow scope.

3. mathematical versus non-mathematical: scenario planning unlike simulations generally makes little use of mathematics. Extrapolation tends to be the most mathematical approach. The minimal use of mathematics is scenario planning should not detract from its use. Maths is a powerful tool when it can be applied, but forcing its application in domains where qualitative factors cannot reasonably be quantified brings only a false sense of precision.

4. predictive versus learning/understanding: scenario planning is not a tool for predicting. Other techniques aim to yield a unique forecast for the future with varying degrees of confidence. In contrast, scenario planning constructs several possible futures, often four. The point of scenario planning is not to find a creative, sophisticated way of justifying existing beliefs about the future. It should challenge those beliefs, reveal previously ignored possibilities and stimulate strategic thinking.

5. subjective versus objective: objective approaches are those that focus on impersonal forces and trends. Subjective (or personal) approaches do not mean arbitrary or unstructured, but the consideration of beliefs, desires, actions and perceptions of people and institutions when constructing forecasts.

3.4.2 Approaches to scenario analysis

As with the definitions and purpose, a range of different methods has evolved for preparing scenarios. Some of the key approaches in the literature are summarised below.

Schwartz (1996 in Mietzner & Reger 2004) uses an approach that starts with the critical issue: what impending decision keeps you awake at night? Then the question is what key factors will determine the success or failure of the critical issue (what are the driving forces creating change in the wider world?). The driving forces are ranked by importance and uncertainty (the most important and the most uncertain). The scenario logics are selected and a scenario matrix is created. The next step is to add description to the scenarios by referring to key factors and the series of plausible events that might create that state (how does the decision look in each scenario?). A SWOT analysis is identified as being helpful. The last step is to find out what might indicators or signposts could be used to identify whether the future is heading toward one or another of these scenarios.

Godet & Roubelat (1996 in Mietzner & Reger 2004) consider that the approach to building scenarios and strategies should draw on simple and rational tools to stimulate imagination, to improve coherence and facilitate appropriation. They have created a tool box which classifies the problem-solving method and uses methods specifically developed for that purpose. However, the approach has been considered too academic, and too dependent on subjective judgements.

To help guide the process of elicitation and discovery, Lempert *et al.* (2004) identify that is can be useful to group the elements of the scenario analysis into four categories (the so-called XLRM Framework):

- exogenous uncertainties (X): factors outside the control of the decision makers but which may prove important in determining the success of the strategies. These uncertainties help to determine the key driving forces that confront decision makers;
- policy levers (L): near term actions that comprise the strategies that decision makers want to explore;

- relationships (R): descriptions of the ways that factors relate to one another and so govern how the future may evolve over time, based on the decision makers choice of levers and manifestation of the uncertainties, particularly for those attributes addressed by the measures (see below); and

- measures (M): performance standards that decision makers and other interested communities use to rank the desirability of various scenarios.

Berkhout & Hertin (2002, in Mietzner & Reger 2004) identify that exploratory scenarios are based on four key assumptions:

- the future is not only a continuation of past relationships and dynamics but can also be shaped by human choice and action;
- the future cannot be foreseen, however, exploration of the future can inform the decisions of the present;
- there is not one possible future only, uncertainty calls for a variety of futures mapping a ‘possibility space’; and
- the development of scenarios involves both rational analysis and subjective judgement; it therefore requires interactive and participative methods.

The starting point according to Shell is to put together a clear description of the scenario project. This exercise can help to clarify aspirations for the project among members of the scenario-building team. The questions to ask are (Shell International 2003):

- what is the primary purpose of the project?
- who will be using the scenarios?
- who is sponsoring the project?
- why has the scenario approach been chosen?
- what are the expected outcomes?
- what time horizon will the scenarios cover?
- how much time is available for the scenario project?
- who will be involved and how much time is required?
- how much will it cost?
- how will the scenarios be applied?

Shell (Shell International 2003) identifies that a scenario structure is comprised of one or more focal questions, a branching point with two or more branches for each critical uncertainty and scenario outlines:

- the focal question: this provides a broad definition of the major challenge(s) that decision makers (users of the scenarios) are likely to face in the future. It needs to be framed in a way that allows exploration of the critical uncertainties that have been identified as being important to the decision makers;

- branches: these are the different directions in which a critical uncertainty could take future events. Each branch will provide a different answer to the focal question. Each answer presents a number of different implications that fundamentally change the environment. Each branch therefore leads to further possible branches, each of which, in turn leads to further branches and further implications; and

- scenario outlines: this is the story that is created by selecting a certain path to follow among the different branches of uncertainty.

Developing the scenario structure is an iterative process, revolving around the focal question, branches and scenario outlines. The structure should reveal clear tensions within and between the scenarios that have strong implications for the decision makers. There are a number of approaches (Shell International 2003):

- deductive: two critical uncertainties are selected and the extremes described on a matrix. Storyline paths are then developed for each quadrant of the matrix with descriptions of how the world could shift from one quadrant to another;

- inductive: a number of different chain of events is selected (no less than three events in each chain) and a plausible storyline is constructed for each chain. From this, a description of how they came about (a scenario structure) can be induced, which will lead to alternative scenarios, which in turn, will help frame a focal question; and

- normative: start with a scenario or set of characteristics at the end of the time horizon and work backwards to see what is required to get there and whether it is plausible. In this way, critical uncertainties are highlighted and can be taken through into the definition of branches and the focal question.

Whichever approach is taken, scenarios will not evolve in an organised, linear fashion. Some aspects of the story will not work as they are inconsistent with other aspects of the scenarios, irrelevant or too vague; these will need to be discarded or reworked. Once the structure and themes of the scenarios have been established, the story of the scenarios needs to be told in a creative and interesting way. When the scenarios are ready, they need to be tested for plausibility, challenge and relevance. The emphasis at this stage should be on clarifying the scenarios, rather than adding new ideas (Shell International 2003).

3.4.3 Approaches to robust decision making

Robust decision tools are appropriate for many problems involving decision making under conditions of deep uncertainty but are particularly powerful for long-term policy appraisal (Lempert *et al.* 2004).

A robust decision approach allows analysts to use computers to identify a wide range of plausible paths into the future. These can then be used to look for near-term policy options, i.e. those that perform reasonably well across a wide range of futures using many different values to assess importance. Often strategies are robust because they are adaptive. The best response to deep uncertainty is often a strategy that is well hedged against a variety of different futures and evolves over time and new information becomes available (Lempert *et al.* 2004).

Robust decision approaches involves the combination of multiscenario simulation approaches with exploratory modelling. Multiscenario simulation approaches use computer models to construct different scenarios while exploratory models use computers to develop a conceptual framework to learn about the world. The approach uses computer visualisation and search techniques to extract information from a wide range, and potentially large number, of plausible future scenarios to help distinguish between alternative decision options (Lempert *et al.* 2004).

There are four key elements involved in robust decision approaches (Lempert *et al.* 2004):

- consideration of a large number of scenarios: these should contain a diverse set of plausible futures to provide a challenge against which to test alternative near-term policies;

- the search for robust, rather than optimal, solutions: i.e. those that perform 'well enough' by meeting or exceeding selected criteria across the broad range of plausible futures using alternative ways of ranking the desirability of the different scenarios;

- use of adaptive strategies to achieve robustness: adaptive strategies evolve over time in response to new information; and

- design of the analysis for interactive exploration of the multiplicity of plausible futures: computer guided exploration of scenario and decision spaces can help decision makers discover near-term strategies that are robust over a wide range of different, plausible futures.

3.5 Strengths and weaknesses of scenario analysis

3.5.1 Strengths of scenario analysis

The key strengths of scenario analysis can be identified as:

- it provides a context for discussing the problem and the decisions to be made;
- it provides a method for challenging strongly held or blinkered views;
- it encourages exploration of uncertainties;
- it allows a wide range of views to be taken into consideration;
- it avoids the need to obtain consensus allowing multiple futures to be determined; and
- it can be used as the basis for monitoring the future and to provide adaptive solutions.

Provision of a common basis for understanding the problem

Scenarios can lead to the creation of a common language for dealing with strategic issues. They also offer a co-ordinating function where, during the scenario process, the aims, opportunities, risks and strategies are shared between the participants. This supports the co-ordination and implementation of actions. In fact, the organisational learning and the decision-making process is improved (Mietzner & Reger 2004).

Furthermore, scenario development provides a context for thinking clearly about the complex array of factors that affect any strategic decision and gives the people involved a common language and understanding of a problem (DG for Security Policy at the Austrian Ministry of Defence 2004).

The large number of scenario techniques highlights that the ways of building a scenario are very flexible and can be adjusted to the specific task/situation (Mietzner & Reger 2004).

Challenge to strongly held views

Experience, training, current fashions and familiar ideas can strongly influence what is noticed and how the world is interpreted. This can leave whole areas about which nothing is known, which can result in exposure to unanticipated developments. Information acquired from discipline-based research can create fragmented learning, which can help to create such blind spots. When planning for the future, there is a need to build a comprehensive picture of the context in which we operate. However, blind spots impose limitations on understanding, so knowledge and thinking needs to be combined (Shell International 2003). Scenarios can help to address this issue by opening up the mind to hitherto unimaginable possibilities and challenge long-held beliefs (Mietzner & Reger 2004)

Scenarios are particularly valuable when there is 'tunnel vision' within a team or organisation, or where there is a need to realign thinking. They are also helpful when a new challenge emerges that is not well understood or there is a requirement to understand and manage the risks inherent in a particular strategy or plan (Shell International 2003).

Decision-makers will often reject projections of the future that deviate from what they expect or what they regard as comfortable. Families of scenarios help overcome this barrier by including in a package, scenarios that decision-makers find comfortable and those that challenge them. In addition, a family of different scenarios can help groups of stakeholders that may otherwise argue according to their different views of the future to acknowledge and accept that many alternative futures are plausible (Lempert *et al.* 2004).

The process of generating scenarios puts communication onto the agenda. Debate is required within the scenario building team to bring the multiple and divergent perspectives of team members into the process (Winterscheid 2006). Schwartz (1996 in Winterscheid 2006) considers scenarios as the most powerful vehicles for challenging our 'mental models' about the world, lifting limits on creativity and resourcefulness.

Exploration of uncertainties

Scenarios can help bring greater clarity to difficult areas of decision making because they acknowledge and focus on what is not known, encouraging the exploration of the nature of uncertainties and helping to understand where the need for judgement lies (Shell International 2003).

Scenario analysis helps to focus thoughts about the future and then to recognise questions surrounding the future and the degree of uncertainty. This often demands a re-examination of the assumptions. It is important to focus on deciding which aspects are relatively certain, which are most uncertain and matter most (Shell International 2003).

Involvement of a wide range of views

Scenario analysis is a collaborative, conversation-based process that facilitates the interplay of a wide variety of ideas and encourages the involvement of different perspectives on an issue or question. It enables different fields of knowledge and ways of knowing to be combined. It also reframes questions, prompting the generation of ideas across disciplines rather than going over old ground. Furthermore, the story form of scenarios enables both qualitative and quantitative aspects to be incorporated, so ideas are not excluded on the basis that they cannot be measured (Shell International 2003). The qualitative narrative gives voice to important non-quantifiable aspects such as values, behaviour and institutions. Scenarios can also provide a broader perspective than model-based analysis, yet at the same time make use of various quantitative tools (GSG 2002).

Scenario analysis encourages the involvement of a wide range of views, rather than seeking a single answer so it is a process designed to accommodate multiple values and opinions. It allows people to explore their ideas about the future context without feeling threatened by the need to fix an immediate decision (Shell International 2003).

Avoidance of the need for consensus and use of multiple futures

It is important to note that ‘foresight’ concepts differ from ‘forecasting’. The strength of scenarios is that the do not describe just one future, but that several realisable or desirable futures are placed side by side (Mietzner & Reger 2004). Unlike forecasting, scenarios do not demand consensus, but rather respect and accommodate differences, seeking only to define them clearly. By building sets of scenarios, several different versions of the future are assembled at the same time. This emphasises that the future is full of possibilities (Shell International 2003).

A multitude of scenarios helps to reduce the potential for ignorant attitudes towards future pathways which seem unthinkable within the present state of information and knowledge (Wintersheid 2006).

Basis for monitoring of the future

Scenarios are most useful if they are used systematically over a period of time, rather than just once in response to a particular situation. To be used in those way, scenarios must be securely rooted in the current reality of the relevant decision makers, embodying the challenges they face and addressing their blind spots (Shell International, 2003).

3.5.2 Weaknesses of scenario analysis

In contrast, scenario techniques have several weaknesses (Based on Mietzner & Reger 2004; Shell International, 2003, and DG for Security Policy at the Austrian Ministry of Defence 2004):

- the practice is very time-consuming, but it is essential that participants are given enough time to generate and describe the scenarios;
- the qualitative approach puts a strong emphasis on the selection of suitable participants, however, in practice this may not be an easy task;
- the qualitative approach means that the information which the scenarios are built upon is imprecise;
- a deep understanding and knowledge of the field under investigation is absolutely necessary. Data and information from different sources have to be collected and interpreted which makes scenario building even more time consuming and heavily expert dependent. This is exacerbated by the iterative nature of the approach where a great deal of learning happens in conversation, making it difficult for anyone coming into the process late, or missing any part of the scenario building process to catch up . For this reason, scenario builders need to commit to participating in all the workshops;
- it can be difficult not to focus on black and white scenarios or the most likely scenario (wishful thinking) during the scenario-building process;
- it can be difficult to translate the outcome of a scenario process into concrete decisions; and
- the scenario technique draws up a ‘possibility space’ that offers the decision-maker a choice of futures. Decision-makers who are used to a solid piece of advice of direction will not always appreciate this.

Lempert *et al.* (2004) focus on two key weaknesses associated with scenario analysis:

- firstly, the choice of any small number of scenarios to span a highly complex future is ultimately arbitrary. A scenario exercise will necessarily miss many important futures that do not make the cut into the top few. Despite best efforts, the logic used to sort the scenarios may seriously bias any conclusions drawn from them. For example, research into the psychology of decision-making indicates that humans gravitate to stories whose plots revolve around a single dramatic event rather than to those whose ending is driven by the slow accumulation of incremental change. Thus, scenario-based planning exercises may make it difficult to think about responses to slowly emerging problems.

- secondly, scenario analysis provides no systematic means to compare alternative policy choices. Although the scenario analysis literature has systemised the process for developing scenarios, the approach for developing policy based on the results is not similarly systematic. Most often scenario exercises stand apart as exceptional practice not formally incorporated into usual decision processes.

4 Scenario analysis for FCERM project appraisal

4.1 Present Guidance

The Treasury Green Book (HM Treasury 2003), in referring to assessing uncertainty, includes both sensitivity analysis and scenarios (Chapter 5).

Sensitivity analysis is stated as being “fundamental to appraisal to test the vulnerability of options to unavoidable future uncertainties”. It goes on to add that “spurious accuracy should be avoided, and it is essential to consider how conclusions may alter, given the likely range of values and key variables”. Scenarios are described as “also useful in considering how options may be affected by future uncertainty. Scenarios should be chosen to draw attention to the major technical, economic and political uncertainties upon which the success of the proposal depends. Considering scenarios needs to be proportionate. It may take the form of asking simple ‘what if’ questions for small and medium sized projects but extended to creating detailed models of future states of the world for major policies and large programmes.”

The former (what if questions) would be appropriate for project appraisals and individual flood risk assessments but larger strategies including large flood risk management strategies such as those for an estuary or river system, catchment flood management plans, shoreline management plans and strategic flood risk assessments may need the additional detail of the latter approach (detailed models).

PAG1 recognises that climate change will not be taking place in isolation. Socio-economic and geographical changes in land use and planning policy will also have an impact on the impacts and occurrence of flooding. It however, does not suggest that these ‘what if’ scenarios are tested within appraisals.

The development of a decision support framework for the Thames 2100 project identified where the use of the scenarios in the Foresight project did not address some of the decisions that need to be made in developing a strategy for the Thames Estuary for the next 100 years. The internal discussion paper for Thames 2100 by Edmund Penning-Rowsell, “Decision Support for TE2100 – Taking Forward the Next Steps” identified how Foresight was different and the areas that were not covered that would have to be addressed in the strategy development. They were that Foresight did not:

- tackle optimisation such that clear ‘winners’ were identified;
- attempt to develop the right mix of portfolios for a mix of geographic situations;
- attempt to balance capital costs and maintenance requirements to give best value for money and did not tackle the problems inherent in discounting;
- attempt to develop sets of options/portfolios that reach to the year 2100 and therefore involved appraising several cycles of investment and maintenance;
- attempt to allow for the possibility of multi-functional options/portfolios; and
- attempt to develop a set of results that meshed satisfactorily with

- other government priorities and other major development; and
- with flood defence plans elsewhere

These are issues that will have to be addressed in the preparation of the TE2100 strategy and illustrates the complexity of scenario analysis and making decisions in an uncertain world.

The Shoreline Management Plan Guidance (Defra 2006) refers to policy scenarios and this appears to be in the context of combinations of policies for managing a particular length of coast over the next 100 years. The timing of any change in policy will reflect a combination of technical, social and environmental factors that change over time. The guidance for assessing policy scenarios is set out in Appendix H (of the SMP Guidance) and includes ranking, percentage compliance and multi-criteria analysis. All three methods use a form of scoring or ranking against objectives.

The three workshops asked a specific question on scenarios – “should scenarios be used?” There was general comment on the need for clear definitions and terminology and also why and how they were to be used. Scenario analysis was seen as complex and requiring additional cost, but could save money in the future. The scenarios should include not just different climate change drivers but also social, economic and political changes.

A problem with using scenarios was how to reconcile the different solutions to arrive at a preferred option. It was considered that this could provide an indication of the need for adaptable solutions to deal with impacts/changes as they arise in the future. Scenario analysis was seen as one way of overcoming the difficulty of predicting over 100 years by having splitting points within the timescale and using this to plan ahead with solutions that could be adapted over time.

5. Scenarios developed in other fields

5.1 Foresight scenario analysis

The Foresight Flood and Coastal Defence Project (OST 2003) identified a 'portfolio of responses' which were assessed in order to quantify their effectiveness in reducing risks, to estimate their costs of implementation and to draw lessons. Foresight stressed that the portfolio of responses was to be regarded as examples of possible futures, rather than predictions or recommendations.

In a way this is not particularly helpful within project appraisal as it introduces another level of uncertainty which is difficult if not impossible to address at the option selection stage. This is not surprising as Foresight's main purpose was to answer the following questions:

- how might the risks of flooding and coastal erosion change in the UK over the next 100 years? and
- what are the best options for Government and the private sector for responding to future challenges?

The need for the study was clearly identified "Decisions taken today will have a profound impact on the size of flooding risks that future generations will need to manage. They will also strongly influence the options available for managing those risks".

In effect there are three strands emanating from the Foresight Project to manage (reduce) the risks to people and the natural and built environments from flooding and coastal erosion that arise from climate change. The three strands are:

- reducing global green-house gas emissions;
- land-use planning; and
- long term planning for flood and coastal erosion defence measures.

Foresight identified the future as "very uncertain and cannot be predicted" and therefore it was important to develop policies that can cope with a range of different outcomes – and which can adapt flexibly as the situation evolves.

The Foresight socioeconomic scenarios have been developed to suggest possible long-term futures. They explore directions in which social, economic and technological changes may evolve over the next few decades. Four scenarios have been developed (SPRU 1999; OST 2002):

- World Markets: high consumerism with power increasingly moving to international organisations;
- National Enterprise: high consumerism but with power retained at the national/regional level;
- Local Stewardship: community-oriented values with power retained at the national/regional/local level; and

- Global Sustainability: community-oriented values but with power moving to international organisations to deal with international problems (e.g. climate change).

A second set of scenarios was then developed, based on linking climate change (greenhouse gas emissions) to the socioeconomic futures. The approach was based on the most likely relationships (e.g. high growth socioeconomic scenario matched with high greenhouse gas emissions). This results in four combined scenarios (based on the Foresight Flood and Coastal Defence Project):

- A1F1: high emissions and World Markets: highest national and global growth. No action taken to limit greenhouse gas emissions. Price of fossil fuels may drive development of alternatives in the long term;

- A2: medium high emissions and National Enterprise: medium-low growth, but with no action taken to limit greenhouse gas emissions. Increasing and unregulated emissions from newly industrialised countries;

- B2: medium low emissions and Local Stewardship: low growth and low consumption. However, less effective international action and low innovation; and

- B1: low emissions and Global Sustainability: medium-high growth but low primary energy consumption. High emphasis on international action for environmental goals (including greenhouse gas emission control). Innovation of new and renewable energy sources.

The drivers identified as being relevant to flood risk in the Foresight flood and coastal defence project are summarised in Table 5.1, with an indication of the extent to which each is considered to be under the control of flood managers. Those drivers where there is high control could be used as responses to flood risk.

Table 5.1 Drivers related to flood risk

No control ← --- -→ High control				
Solar activity Earth's orbit	Global values Global prosperity Global greenhouse gas emissions	European policy and regulation Natural prosperity Public perceptions Insurance industry	Urban and rural land use Building practices	Flood defences Flood forecasting and warning

The key uncertainties for flood risk management identified in the Foresight report include:

- uncertainties in the scenarios of greenhouse gas emissions and socioeconomic change;
- uncertainties in model simulations of climate and flood risk; and

- uncertainties in feedbacks between evolving flood risk and the ways in which society and the environment will respond and adapt.

This type of scenario analysis is very useful in the policy context but there are drawbacks in using the same method at the process appraisal level which is being undertaken in the short term. That is decisions are being made now in response to a problem that needs addressing (such as failed defences, increased risk of flooding, etc.) but the decision has to be made in an uncertain world regarding not just climate change but also potential changes to the built and natural environment. For example, changes over the last 50 years include the closing down of the majority of the coal mines in Britain with resulting social consequences, and changes to types of holiday being taken which has had far reaching consequences on many seaside resorts.

The scenarios in Foresight are just that – scenarios - and whereas it would be possible to identify four different scenarios for each flood risk management option being assessed there would still be the question of uncertainty over which of the scenarios should be chosen?

What is therefore required is a way of ensuring that decisions made now will allow for adaptation in the future when there is more certainty over not just the input parameters (sources) but also the impact areas (receptors).

One PAR, Warden Bay Coast Protection Scheme, includes an estimation of future erosion rates under the four Foresight scenarios. They varied from 1.67m/yr to 2.37m/yr compared to the 1896-1966 average of 0.91m/yr. The economics was then based on 2m/yr over the next 100 years which Defra commented as excessive as the 2m/yr may only be applicable in the longer term and therefore should have been used as a sensitivity test.

5.2 World Business Council for Sustainable Development global scenarios

Of the many possible scenarios that could be constructed, all begin with three pre-determined elements: the new, the many and the connected. These are the driving forces that shape the environment and will persist in any scenario. They form the common starting point from which the scenario emerge and then diverge (WBCSD nd).

- the new: social and technological innovations, new players in the economy (new businesses, new roles for existing organisations);
- the many: people; and
- the connected: interconnections between people and the environment, economy and environment, etc.

Three scenarios have been developed to explore possible responses to the challenge of sustainable development (WBCSD nd):

- FROG! (First Raise Our Growth): scenario that ignores social and environmental problems, trusting in the dynamic of economic growth and the innovations of technology. Sustainable development is valued, but it is not top priority. In the early years, local environmental health in many areas improves significantly, but at the global level, the picture is less clear. With economic growth and the increase in population, greenhouse gases are rising, unnoticed by most;

- GEOpolity: when problems reach a crisis point, this scenario turns away from ineffective institutions of government and business to seek new models of governance. This results in an interlocking governance structure coordinated at the international level such as the Global Ecosystem Organisation (GEO) which has broad powers to design and enforce global standards and measures to protect the environmental and preserve society, even if doing so requires economic sacrifice; or

- JAZZ: scenario that embodies growing environmental and social values, experimenting with ad hoc alliances and innovative forms in a world where everything that is done is open for everyone to see and judge. This results in markets that are harnessed to finding solutions to sustainable development. This is a world of social and technological innovations, experimentation, rapid adaptation, much voluntary interconnectedness and a powerful and ever-changing global market. High transparency (the widespread availability of information about ingredients of products, sources of inputs, company financial, environmental and social data, government decision-making criteria, etc.) enables quick learning and subsequent innovation. This allows new actors to step onto the economic stage. That stage itself is characterised by a global free market, sound legal systems and a respect for property rights.

5.3 Global Sustainability Group scenarios

Global futures cannot be predicted due to three types of unknowns (GSG 2002):

- ignorance: incomplete information on the current state of the system and the forces governing its dynamics leas to a statistical dispersion over possible future states;
- surprise: even if precise information was available, complex systems are known to exhibit turbulent behaviour, extreme sensitivity to initial conditions and branching behaviours at critical thresholds. The possibility for novelty and emergent phenomena render prediction impossible; and
- volition: the future is unknowable because it is subject to human choices that have not yet been made.

To organise thinking about global futures that could emerge from the turbulent changes that are shaping the world, the immense range of possibilities needs to be reduced to a few stylised storylines that represent the main branches. The Global Scenario Group includes three classes of scenarios (GSG, 2002):

- conventional worlds: assumes that global system in the 21st century evolves without major surprise, sharp discontinuity, or fundamental transformation in the basis of human civilisation;
- barbarisation: foresees that social, economic and environmental problems are not managed, instead they cascade into self-amplifying crises that overwhelm the coping capacity of the conventional institutions resulting in fundamental but undesirable social change. Civilisation descends into anarchy or tyranny; and
- great transitions: envisions profound historical transformations in the fundamental values and organising principles of society. New values and development paradigms ascend that emphasise the quality of life and material sufficiency, human solidarity and global equity, and affinity with nature and environmental sustainability.

The point of departure for all scenarios is a set of driving forces and trends that condition and change the system (GSG 2002):

- **demographics**: changes in global population;
- **economics**: Governments face greater difficulty forecasting or controlling financial and economic disruptions caused by ever greater globalisation and an increasingly interdependent world;
- **social issues**: increasing inequality and persistent poverty characterise the contemporary global scene and economic inequality is growing;
- **culture**: globalisation, information technology and electronic media foster consumer culture in many societies; this is both a result and a driver of economic globalisation;
- **technology**: the continued advance of computer and information technology is at the forefront of technological innovation;
- **environment**: global environmental degradation is a significant transnational driving force. The realisation that individual countries cannot insulate themselves from global environmental impacts is changing the basis of geo-politics and global governance; and
- **governance**: there is a significant trend towards democracy and decentralisation of authority.

6. Scenario analysis in practice

6.1 Overview

The review of guidance documents and PARs has identified the need for a clear definition of scenario analysis. The SMP guidance includes numerous references to scenarios but in nearly all cases it refers to policy scenarios which are the policy options.

However, SMP2 does recognise the need to include future changes in developing appropriate strategies for managing the coast and the problems that are likely to arise. The areas that could be affected are identified as:

- *areas that will continue to change due to erosion or accretion;*
- *areas that will be increasingly at risk from flooding, erosion or instability;*
- *areas where maintaining existing defences is likely to become increasingly difficult or expensive; and*
- *areas that will become increasingly important to the shoreline and coastal defences, such as inter-tidal flats providing protection from waves.'*

The SMP2 guidance also gives the recommendation to look at potential changes over three epochs; 0 - 20, 20 - 50 and 50 - 100 years from present.

The future changes to be taken into account when preparing SMPs relate primarily to those associated with climate and geo-morphological change.

The CFMP guidance takes a slightly different approach in that it involves the assessment of various influences that can make a difference to the flood risk (probability and consequence) of flooding in the catchment (Vol 1 S4.6.1). To this end it recommends investigating potential changes such as:

- land use , such as new development or significant changes in the developed environment;
- changes in the rural landscape, including large scale changes in land management;
- loss of, or potential threat to, wildlife habitats or biodiversity; and
- measures to reduce the effects of floods on communities; and climate change.

The MDSF Software displays data (Vol 1 S1.2) '*on the basis of "Cases". A Case is a combination of three "scenarios": climate, land use and flood risk.'* Land use scenarios can include:

- present day;
- urban expansion; and
- agricultural land use change.

Flood risk relates to flood risk management and can include sustain as present day, improve or retreat.

It is interesting to note that the CFMP Guidance states (Vol1 S4.6.1) that the baseline data provides the benchmark information for the policy appraisal but also that the existing state, current trends and future evolution of the baseline should be documented. The current level of management is the baseline in the CFMPs and not do-nothing, as is (generally) the case for project appraisals (strategies and schemes). The evolution from the baseline is a scenario that is modelled for the potential future impacts both spatially and temporally.

6.2 Broadland Rivers CFMP

Approach

The Broadland Rivers CFMP (Draft Report June 2006) has used combined future scenarios to assess the risk in 50 and 100 years. These are shown in Table 6.1.

Table 6.1 Broadland Rivers CFMP combined scenarios

Scenario component	**50 years from present**	**100 years from present**
Sea level rise and land subsidence (combined)	0.3m	0.6m
Flood flows	20%	20%
Urbanisation (based on East of England Plan)	2055 high growth	2055 high growth

These two scenarios against the baseline gave information on the increased risk that could be expected as shown in Table 6.2.

Table 6.2 Broadland Rivers CFMP future damages

Time from present	**Property AAD Upper Bure/Ant (rural)**	**Number of properties affected in 1%AEP Upper Bure/Ant (rural)**	**Property AAD Norwich (urban)**	**Number of properties affected in 1%AEP Norwich (urban)**
Current	£355k	91	£335k	38
100 years	£388k	97	£540k	231

Benefits

Although the results are obvious the scale and location give assistance in prioritising where effort is required to make changes to flood risk management and monitoring to reduce future risk.

Potential pitfalls

The scenarios used are limited and the analysis more of a sensitivity analysis. This then does not explore development or climate change scenarios in any depth which could lead to options that are not optimal or sustainable.

Links to FCERM

This is a FRCEM project being used to set policy.

6.3 South West Lakes CFMP

Approach

The South West Lakes CFMP took a slightly different approach (Scoping Report). It looked at three epochs (present day to 20, 20 - 50 and 50 - 100 years). The following scenarios were tested:

- urban development/decline;
- industrial development/decline;
- agricultural land use change; and
- climate change.

Additional urban areas were taken from local development plans '*which were used in place of the 10% increase recommended by the CFMP guidance'* as they were lower. The additional urban area modelled extended to 4.3km^2 and changes to land use were also modelled relating to tree planting and agricultural land use. Some of the results are shown in Table 3. The changes from land use are much greater than those associated with urban developments and the 81% increase for Whitehaven is well above the 20% increase in flow that Defra suggest as a sensitivity analysis.

Table 6.3 Changes to flow from scenarios used in SW lakes CFMP

Location	**Existing 100yr peak flow (m^3/s)**	**% increase from urban development**	**% increase from land use change**
Whitehaven	9.1	29	81
Barrow	24	6	32
Egremont (Beck Green)	160	0	28
Beckermet	21	0	27

The present Defra guidance on climate change for fluvial flows recommends a sensitivity analysis for a 20% increase by 2050 with a 10% increase in 2025 (PAG2). A graph shows how this is used with the probability - the return period decreasing over time. This approach, it is stated, '*should be used as the basis for appropriate sensitivity testing of options and their benefits*.'

PAG2 recognises the current uncertainty in possible increase in peak flows and recommends that it is preferable to consider design options which will allow for future incremental adaptation.

Benefits

It would appear from Table 3 that both potential land use changes and urban development could result in peak flows greater than those suggested by Defra. This then gives the opportunity to not just look at flexibility in design but also changes to land management and planning as an option to reduce flood risk. Managing risk through development control is now established with PPG25 and the soon to be published PPS25 but controls/changes to land use for reducing risk is not as well developed even though it could have a far greater impact.

Potential pitfalls

A potential pitfall is that the worst case scenario may be used to set policy now and climate change, land use and development may not change as modelled. This could lead to policies that are not appropriate.

Links to FCERM

This is a FRCEM project to set catchment policy.

6.4 Avon River Estuary project, New Zealand

The Review and Depth Evaluation of Social, Economic and Environmental Costs and Benefits Evaluations for Flood Risk Management in Estuaries report undertaken as part of the FRaME project (FRaME 2004) identified three projects where scenario analysis had been used in the appraisal process.

Approach

The Avon River Estuary project in New Zealand (in FRaME 2004) used current, 50 and 100 year scenarios to assess damages under various mitigation options with sea level rises of 0.15m and 0.4m in 50 and 100 years respectively. The mitigation options comprised two non-structural measures, minimum floor heights and sub-division control and two structural measures, flood banks and tidal barrages. Only economic impacts were valued with impacts on the environment (ecosystems and water resources) described qualitatively and stakeholders views were an integral part of the appraisal process. However, it is unclear how the scenarios informed the choice of policy option.

Benefits

Although the benefits cannot be clearly identified from the project there is a demonstration of using scenarios to widen the scope of options to manage flood risk. The use of stakeholders within the appraisal process is usually beneficial but again there is not the information to show whether this was the case.

Potential pitfalls

The number of options together with sea level rise at two different rates and over two time periods can generate a large amount of data that is not easy to handle and therefore clouds the appraisal process.

Links to FCERM

Useful link with FCERM project that also looks at non-structural measures.

6.5 IRMA-SPONG Umbrella program

Approach

The IRMA-SPONG Umbrella Program (in FRaME 2004) included a scenario study which combined physical modelling with socio-cultural theory. Existing climate, land use and socio-economic scenarios as well as water management strategies were structured using the “Perspectives Method”. This is a matrix type approach where the implications of each scenario are assessed using quantitative and qualitative information. The evaluation criteria used to assess each scenario were;

- safety (probability of catastrophic events);
- nature (area of nature, biodiversity, etc);
- agriculture (area of land and potential impacts from drought or floods);
- costs (of measures);
- economic benefits (for defined economic sectors);
- flexibility/reversibility (ability to adapt);
- quality of life (area for recreation and type of activity);
- resilience (ability to recover from flooding); and
- inland navigation (positive and negative effects).

The method then uses negative/positive scales and a form of scoring and weighting to compare options through a Decision Support System. The method also includes sensitivity scores as indicators for uncertainty.

Benefits

A wide range of evaluation criteria were used and the matrix approach can provide an accessible methodology. It is a comprehensive method that uses both qualitative and quantitative information and also gives levels of uncertainty.

Potential pitfalls

The large amount of data required requires effective management. The approach must be easy to understand in the way that it is presented otherwise it becomes a ‘black box’ methodology with no audit trail.

Links to FCERM

This is a flood risk management project.

6.6 The Erne Catchment, Ireland

Approach

The Erne Catchment in Ireland is a large wetland area with a vast natural flood storage capacity. As part of the Wise Use of Floodplains the Erne Sustainable Wetlands project (in FRaME 2004) was set up identify ways of achieving integrated and sustainable water and land use. Scenarios consisting of management proposals were developed through participatory workshops. An integrated approach to appraisal, the Local Sustainability Model was used to compare options against a baseline. This took a matrix approach and used mainly financial indicators.

Benefits

The method is driven by stakeholders and does not explicitly address uncertainty but is easy for stakeholders to understand and participate in.

Potential pitfalls

The use of participatory workshops unless strictly facilitated may limit the scope of options or provide such a wide range of options that appraisal becomes unwieldy. It is not clear how the baseline was assessed which is vital to the appraisal methodology which compares options against the baseline.

Links to FCERM

This is primarily a local water level management project but could provide useful information for FCERM appraisals especially in stakeholder participation.

6.7 Climate change and water resources

Approach

A recent study by HR Wallingford for Defra (HR Wallingford 2006) uses a scenario based approach to assess the impacts of climate change on water resources and to identify the least-cost (i.e. most sustainable) set of responses (see also Task B2 report). The approach used is an objective-led appraisal with the aim of identifying the most cost-effective combination of options to meet a range of supply-demand deficits determined by the UKCIP and Foresight scenarios. The socioeconomic Foresight scenarios result in some options being identified as ‘unacceptable’, for example, ‘new reservoir’ is not acceptable under the Global Sustainability scenario, while ‘white goods subsidies’ is not acceptable under the National Enterprise scenario. The project, therefore, considered what action might be required to make sure that cost-effective options could be implemented in the future as opinions and expectations change.

Benefits

The methodology allows for explicit consideration of different future scenarios when identifying which options should be implemented. The approach includes an iteration whereby actions that would be necessary to make options applicable under all of the scenarios are considered. For example, 'white goods subsidies' could be included under the National Enterprise scenario if the option is modified to include an economic instrument where a tax is applied according to the water use rating of the white good (as measured to assign a water use rating to the white good). The tax would be variable according to the difference between the white good being rated and an 'AAA' rating. The best rating (and hence tax differential) could be modified over time to take account of improvements in water efficiency. The use of scenarios is this manner helps to identify a range of actions that are likely to be required if the most sustainable options are to be implemented.

The approach also helps identify key times when particular actions would be required. This could be used to maximise the potential for a low regret set of responses. This would occur where some actions are implemented now, but other actions are postponed until some time into the future when more would be known about the change in supply-demand for water resources and, thus, whether the option is still required or whether 'more' (or less) of the option is needed (e.g. building a bigger reservoir rather than constructing a reservoir now that in ten years time has to be supplemented by a second reservoir).

Potential pitfalls

The approach requires a detailed analysis of all options under all scenarios. This is very time-consuming and also requires more data than would be the case for a 'traditional' (i.e. non-scenario based) decision-making methodology. There is also no mechanism for determining how the actions required to ensure that an option can be implemented under all scenarios would be enforced. This increases the risk that there are different sets of preferred combinations of options according to the scenario being considered.

Links to FCERM

The methodology used could have relevance to FCERM projects, for example, where future adaptations may require higher and higher defences. This may not be acceptable in the future such that other, non-structural solutions may need to be examined. Clearly, there is further uncertainty introduced in trying to predict future attitudes (although this is covered by the Foresight scenarios), but it again highlights the importance of identifying and appraising options that are flexible and adaptable now such that future generations are not tied into solutions that do not meet their particular requirements or preferences.

6.8 Clear Water Creek watershed, Texas, US

Approach

The approach was based on development of a number of models to represent a variety of hydraulic conditions (Benavides *et al.* 2001). The scenarios used represented attempts to model the effects of small-scale channelisation through an area of Friendswood, Texas.

Benefits

The main benefit of using scenarios was that they showed, no matter what level of channelisation was employed, that some of properties would still be flooded. This provided information on which properties would be best removed from the 100-year floodplain by property buyout.

The approach also had benefits in that it allowed other impacts (particularly environmental) to be considered in the decision-making process. This was achieved by including channelisation scenarios that were more sympathetic to the sensitive ecosystems in the area. The results showed that major channelisation offered fewer (flood risk management) benefits over small-scale channelisation.

Potential pitfalls

The need for an accurate digital floodplain of both the pre- and post-channelisation scenarios together with sufficient data to calibrate the hydraulic model added significantly to the complexity of the exercise. There was a lack of accurate high water data from historic storms, so another method of calibration had to be found (and was difficult). The approach used was to plot properties that had been known to flood on different events.

Links to FCERM

The model, once developed, was used to assess various flood control options. However, the model has to be specified for the area in question.

6.9 Integrated scenario approach for spatial planning and natural hazards mitigation

Approach

The study addresses the topic of urban growth and decentralisation from a scenario approach (Barredo *et al.* 2005). An urban and regional growth simulation tool (MOLAND) is used as part of an integrated methodology based on a set of spatial planning tools that can be used for assessing, monitoring and modelling the development of urban and regional environments. Based on alternative spatial planning and policy scenarios, the model then predicts the likely future development of land use.

The report includes five case studies, three of which are related to flooding (Pordenone Province, Friuli-Venezia Giulia Region, Italy; Dresden-Prague corridor; Pärnu City (Estonia)).

Pordenone Province (Friuli-Venezia Giulia Region, Italy)

Future urban scenarios are produced by taking into account several factors – land use development, population growth or spatial planning policies. Early results of the study showed that the main driving force of natural disasters is not only increasing flood hazard due to climate change, but increasing vulnerability, mainly due to urbanisation in flood prone areas.

Two future simulations were produced – the first represented a fairly compact development style for the urban nuclei in the Province of Pordenone; the second was based more on past trends and showed a more scattered development style for new built-up areas. These two simulations were used for the flood risk assessment (the flood hazard areas were assumed to remain stable over time, which may change under changing climate conditions), however, the flood risk increases over time.

Dresden-Prague Corridor

Three scenarios of urban land use were developed:

- the business as usual scenario: this assumed moderate growth and is based on trends for the end of the 1990s. Industrial land use demand is foreseen not to grow in the area
- built-up expansion scenario: based on economical and environmental assessment under the European Baseline scenario (published by EEA in 2005). Demand for residential land is assumed to increase by 50% for low and medium built-up density classes. For commerce and services, demand doubles and the importance of fast transport links grows.
- motorway scenario: the same land use demands are used as for the built-up expansion scenario but the role of the motorway between Dresden and Prague is reinforced in terms of regional development. This leads to the setting up of commercial and services sites in its surroundings, in what are predominantly rural areas.

Overlaying the land use datasets with a flood hazard model layer shows the increasing exposure to floods in the area. The future trend is in that direction unless measures for land use management are effectively applied.

Sea Level Rise Assessment in Pärnu City (Estonia)

Two development scenarios were produced through modelling: business-as usual and 'optimistic'.

The business-as usual scenario assumes that urban trends from the past 5 years remain the same. This results in development on the city edges, industrial land in the inner city is steadily substituted by commercial and the appearance of new urban clusters outside of the core area is limited.

The optimistic scenario is based on the vision of the Pärnu City Council planning authorities. The city of Pärnu is an example of good practice in planning. Both the Local Agenda 21 and Pärnu General Development Plan 2001-2025 have been compiled and state that development will more sustainable and balanced with multifunctional use of urban space. The banks of the Pärnu river are planned to be converted to attractive residential and leisure areas instead of industrial use. New residential development has also been designed along the river.

Climate change is expected to result in new environment and socio-economic threats for thee city, with the expectation that storm surges will be more probable in the future. Pärnu is extremely vulnerable to flood events as it is only around 10m above sea level. Coastal erosion and landward intrusion of saltwater may affect both sand beaches and lowland coastal ecosystems.

Three climate change scenarios were used: low case scenario, where the lowest values for wind speed, discharge from river basins and ice cover are used and projects a 9cm sea level rise in 2100. The 'ensemble average' scenario estimates a 56 cm sea level rise in 2100 while the 'high case' scenario estimates sea level rise of 108 cm in 2100.

The increase in urban areas that are likely to be flooded varies from 20% to 170%, with the maximum impact in the city centre where the historical buildings are located.

Storms in January 2005 showed that the existing 1m high sea walls would not be enough to cope with future extreme events. The scenarios allow awareness to be raised among the public and authorities. This should lead to a flood defence and urban planning integrated strategy to be implement to mitigate the effects of surge floods.

Benefits

The approach shows the potential for land-use based food impact assessment to inform future land use management, and future damage potential and exposure trends. It reinforces the message that only an integrated strategy combining hazard mitigation and exposure and vulnerability management will mitigate flood disasters.

The scenario approach also offer potential for awareness raising and provides the basis for the ability to plan for future extreme events.

The approach encourages interaction with local stakeholders, necessary to gain knowledge on the local area. This can also encourage setting up of formal collaborations to exchange knowledge between regional and local stakeholders.

Potential pitfalls

The approach needs to include a wide range of different processes, which also have to be analysed and properly understood. This is time consuming and requires a lot of data and/or expert involvement, in particular for calibration of the models. In some cases, the information is not available which affects the likely accuracy of the modelling phases.

Links to FCERM

The case studies looked at links between spatial development and exposure to flood risk and identified the role that planning plays in controlling exposure to flood risk.

6.10 Brisbane Bremer River System

Approach

Three storm scenarios were identified:

- local tributary storm: localised short duration (2 to 6 hour) producing fast flow velocities and high flood levels in the upper reaches;
- Bremer River storm: more widespread longer duration, producing high discharges at the lower end and backwater effects in local tributaries; and
- Brisbane River storm: regional extent and long duration (30 hour), producing high peak discharges at the junction of the Bremer River and with tributary backwater effects.

The storm scenarios were combined and their predicted flood profiles overlapped to determine the maximum envelope of flood levels in the area. This showed that the Brisbane River flooding scenario predominantly influences flooding in both the Brisbane River and Bremer River tributaries. Flooding in the upper reaches of the tributaries was generally found to be due to local catchment effects.

Benefits

The combination of storm scenarios provided much greater insight into the potential impacts of flooding across the Brisbane Bremer river systems. This allowed more holistic solutions to be considered.

Potential pitfalls

The approach required considerable data resources to model the predicted flood levels and flood envelope. The project relied on historical information (such as photographs and flood records) to supplement the available quantitative data.

Links to FCERM

The project was directly related to assessing flood risks in Queensland.

7. Guidance and practice on climate change

7.1 Present guidance on climate change

PAG1 includes a whole chapter (Ch. 6) on climate change. There is discussion on research relating to sea level rise, precipitation, and wind and surges, and comment on the present uncertainty surrounding predictions. There is reference to PAG3 for the allowances to use in appraisals for sea level rise and a description on how to include an adjustment for increased river flows.

The main thrust of PAG1 in respect to climate change is the need to allow for possible future adaptation. It also points towards the need for a precautionary approach to risks, the identification of short term 'no regrets' actions and longer term 'adaptation responses'. A strategic approach to the management of flood and coastal defences is identified as crucial for dealing with the identification and implementation of policies and measures.

PAG2 includes guidance on 'Considering Risk' and states that: "Analysis of risk and sensitivity will play a significant role in option assessment". It also states that: "Assessment should include the sensitivity testing of a range of alternative policy scenarios". However, there is no guidance as to how this can be done.

PAG3 gives regional annual rates of sea level rise to be used over the appraisal period. It also states that assessments should consider secondary effects such as changes in wave height but gives no indication on how this may be incorporated apart from including it in a sensitivity analysis.

PAG4 refers to the annual rates of sea level rise and states that these should be used as predictions over the appraisal period. For fluvial projects PAG4 refers to IoH research for the Severn and Thames catchments that indicates increases of up to 20% in peak flows could be experienced under climate change within 50 years. Until there is more certainty it is suggested that this 20% is included as a sensitivity analysis.

PAG4 also states that in exceptional cases, where very long data records are available regionally, it may be possible to make predictions from historic trends, though there can be no certainty that these will reflect the future rate of change.

PPS25: Development and Flood Risk gives allowances for relative sea level rise that are to be used as a "starting point for flood risk assessments". It comments that the rise in sea level will change the frequency of occurrence of high water levels and points to the possibility of secondary impacts such as changes in wave heights due to increased depth as well as possible changes in frequency, duration and severity of storm events. PPS25 states that a 10% sensitivity allowance should be added to offshore wind speeds and wave heights by the 2080s.

For rivers, PPS25 states that for flood risk assessments, an increased peak flow allowance of 20% for a given return period by 2050 and 30% by 2110 may provide appropriate precautionary response. The increases for rainfall intensities are given as 10% by 2050 and 15% by 2110.

Indirect impacts are also referred to where changes in land use and land management may increase future flood risk. The examples given are changes in crop type, methods of cultivation and harvesting which could affect the porosity and surface of the ground and hence volume, speed and direction of storm run-off.

PPS25 also identifies the need for an integrated approach across different sectors including land use, water resources, transport, biodiversity and recreation for adaptation to climate change. It states that this integrated approach should be reflected in flood risk assessments but does not give any indication or guidance on how this can be carried out.

7.2 Present practice in FCERM appraisals

The present practice within PARs is varied but generally follows the guidance in that sea level rise is included in damage calculations for tidal/sea defence projects and 20% increase in flow is included as a sensitivity analysis for fluvial projects. However, this appears to be undertaken in a mechanistic way with little or no thought or analysis of the implications for optimisation or sustainability of options. R&D project FD2020 carried out limited consultation on adaptation options identified in a selection of PARs as follows:

a) Burton on Trent: The design standard of protection is 1 in 200 year. The impact of climate change was assessed using the 20% increase in flows in the River Trent. However, the defences cannot be raised without raising the railway line, which is not economically viable. Therefore, the decision was to bear the potential increased risk and accept that the standard of protection in 50 years time (with 20% increase in flows) might reduce to as much as 1 in 65.
b) Around Cheltenham the decision was made to try to accommodate possible increases in peak flows by increasing storage capacity on the flood plain.
c) In Cannock the capacity of the culverts under the A5 was increased to accommodate the 1 in 100 year flow and a possible increase in this flow of 20%.
d) Humber Estuary: The Humber Flood Risk Management Strategy is currently working its way through the internal and external approvals process. The strategy looks at managing flood risk over the next 100 years but focuses on the challenges of the next 50 years. One of the principal challenges is sea level rise, which is currently 2mm per year, expected to rise to 6mm per year. There is a five-year package of capital works attached to the strategy with £80m of work in the period 2007-2012. These works are a combination of raising and strengthening existing defences on line and managed realignment. The realignments are driven by four factors - seeking shorter, more economic lines of defence, retreating in areas where issues such as erosion are most severe, allowing the estuary to spread into additional areas to reduce extreme flood levels and allowing space for the

estuary habitats to migrate inland to counteract the effects of coastal squeeze.

e) Lymington Flood Alleviation Scheme: The scheme is principally to protect against fluvial flooding, although it is also just upstream of the tidal limit. A sensitivity analysis has been carried out by adding 20% to the fluvial flood flows. This shows that the required design level needs to be 50mm higher. Also, the impact of a tidal event of 1 in 200 on the fluvial scheme has been assessed. The tidal event includes the recommended allowances for climate change. This shows that the required design level needs to be 300mm higher. Therefore, an allowance of 300mm has been added to the design level and will cost about £60k. This more than allows for the 50mm climate change for fluvial flows and meets the tidal event climate change level.

f) Estuary studies in Essex and Suffolk: The Roach & Crouch, Blackwater, Orwell, Alde and Blythe need to adapt to sea level rise and the objective is to achieve a sustainable plan by identifying areas for managed retreat and implementing works to create inter-tidal habitats.

The conclusion by the FD2020 project team was that:

"These experiences exhibit a range of adaptation responses, from applying the guidance and accepting the increased risk, to developing adaptation responses to reduce these potential increases in risk".

Of particular interest is the relatively small number of examples that there are of practitioners applying the guidance (these were compiled by the Environment Agency), but the variety of responses within this small set. This rather implies that the guidance needs development in terms of some additional detail on the blanket 20% that currently exists. The detail should be in the form of regional, or more catchment-specific information, and include information pertaining to alternative time horizons in the future (the current guidance is only explicit for changes in peak flows up to the 2050s)."

Thames 2100 has identified four climate change scenarios for use in the early Conceptual options (ECOs) testing. These are Defra (2003), UKCIP02 Medium High, High Plus and High Plus Plus. The latter two scenarios are loosely based on physically possible changes, intended to represent plausible, if unlikely, future climate change developments.

The results from the review of PARs (Task B1), although not specifically asking questions relating to climate change scenarios agrees with the above observations (see also Task A1 report).

The workshops asked specific questions on future changes, uncertainty and sensitivity analysis. The discussions identified a very clear need for guidance on climate change especially for fluvial assessments. The inconsistency between development control and flood risk management was highlighted as a problem as were lack of links with the more recent Foresight and MSfW reports.

There was also concern that sensitivity analysis is undertaken as the final part of the appraisal and therefore often suffers from time and budget constraints resulting in a superficial analysis which may not add value to the decision making and hence lead to the ‘wrong’ preferred option being chosen.

8. Conclusions

8.1 What scenarios have to offer

The use of scenarios can provide valuable information to the decision makers on potential impacts from future changes. The potential changes can include those associated with climate change, land use, social behaviour, and combinations thereof. The one thing all these potential changes have in common is that there is uncertainty as to the timing and degree of impacts.

Within the context of this project on the Evidence Base for Appraisals, scenario analysis is considered as the means by which adaptation for possible (uncertain) changes to source data (such as sea levels, increased rainfall, storminess, land use, etc.) is brought into decision making.

There is a wide range of potential uncertainties when dealing with flood and coastal erosion risk management from both drivers and receptors, and different levels of analysis have been used from simple increases in run-off as a sensitivity analysis to the more complex Foresight scenarios. However, for scenario analysis to inform decision making the scenarios must be relevant, possible and clearly defined. The scenario analysis must also be presented in such a way that it informs and assists the decision making process and does not add to confusion and complexity.

The evidence gathered for this project has identified a number of ways of approaching scenario analysis from taking potential projections for climate change to using stakeholders to identify possible management/land use changes. What has been found to be missing is any methodology or guidance on how the results of the scenario analysis should be used in decision making. Obviously care has to be taken otherwise the uncertainty will drive the decision-maker not to make a decision.

Winterscheid (2006) identifies that scenario analysis applies where:

- the flood risk management problem is related to the future;
- the issue under consideration is complex;
- there is irreducible uncertainty; and
- decisions are embedded into a collaborative and conversation-based process.

The approach can be applied at different levels (Winterscheid 2006):

- catchment wide levels: e.g. flood risk scenarios for major European river basins. They can serve as an universal reference for communication purposes and for policy development; and
- local/regional scale: e.g. scenario studies for the future of cities and regions, which are threatened by exposure to flood risk.

Table 8.1 summarises some of the key problems faced by flood risk management that could be addressed by the use of scenarios.

Table 8.1 Summary of potential benefits of scenario analysis for flood risk management (based on Winterscheid 2006)	
FCERM problems	**Potential benefit when using scenario analysis**
Complexity, uncertainty and areas of conflicts generate multiple and often divergent perspectives within a group	Scenario analysis allows multiple scenarios to be generated and despite differences between group members, scenarios generate a common language (Ringland 2002)
Complexity hampers access to the system structure	Scenarios challenge mental models about the world and reduce limits on creativity and resourcefulness (Schwartz 2002)
Difficulty of communicating and understanding flood risk	The narrative and participative form of scenarios allows stakeholders to include their knowledge in the generation phase and can also help improve flood risk perception
Decreasing support for the implementation of measures in times without flooding	Scenarios are a forum for learning. Their presentation to external groups will stimulate feedback and debate (Ringland 2002)

However, Winterscheid (2006) also identifies that research is needed to define the particular needs, procedures and requirements for the application of scenario analysis to flood and coastal erosion risk management problems.

8.2 Practical application

The examples used in this report show the various ways scenarios have been analysed and in some cases used to inform the decision. However, it can be seen that scenario analysis is not well developed or understood within the appraisal process (not just in FCERM but in other fields as well).

The present FCERM guidance on sea level rise is not used in a scenario context but as a given and this is readily incorporated in the majority of appraisals. This tends to obscure the uncertainty surrounding sea level rise (over and above that already happening), possible increased wave action and storminess. The same is happening with uncertainty surrounding changes in rainfall and runoff. The present guidance suggests a sensitivity analysis of an increase of 20% in peak flows. This is often undertaken for fluvial projects but not in a way that is thought provoking and informs the decision. Even when the sensitivity analysis is used in the decision for the preferred option, such as in the Cannock PAR, there was no consideration of what would be different if the runoff was greater than 20%.

There therefore needs to be guidance on how scenario analysis can be used as an integral part of the appraisal process to give better decisions that take future uncertainty into account.

In order to be able to use scenario analysis an agreed definition is required to ensure that there is a consistent approach within the FCERM field. This could be developed as part of new guidance and suggested definitions are as follows:

‘A scenario is a possible future situation and includes a description of the developments that have led to that particular future.’

‘Scenario analysis is a tool for improving decision making against a background of possible future environments. It helps us rehearse our response to those possible futures.’

This is then different from sensitivity analysis which does not include a description of how that possible future situation may arise.

Scenario analysis could lead to solutions that are adaptable over time and can accommodate changes as they occur. Guidance on scenario analysis should include the following:

- scoping of possible changes to drivers;
- scoping of possible changes to receptors;
- screen out any that will have little or no effect;
- analyse the options under different scenarios;
- screen out options that cannot be adapted (or consider costs of getting it wrong);
- compare remaining options (combining if necessary); and
- choose ‘preferred’ option that provides optimal solution (in terms of risk reduction, maximum benefit, least cost and potential for adaptation).

The review of PARs and results of consultation point to the need for guidance that is easy to understand and be implemented by practitioners and therefore has to be fit for purpose. This extends beyond sensitivity analysis to scenario analysis to explore the effects of potential changes to drivers and receptors. The challenge will be to provide this guidance in a way that can be used effectively and efficiently and that will affect (improve) the way decisions are made.

As a first step to using scenario analysis within FCERM project appraisal the questions asked by Shell International could be a good starting point as illustrated below:

- *what is the primary purpose of the project?* – to identify the most robust and sustainable solution to reducing flood risk to people and property, to spend money in the way that provides best value for money, taking into account potential future changes
- *who will be using the scenarios?* – Defra, EA, consultants, but also stakeholders
- *who is sponsoring the project?* – Defra, EA, any private contributions?
- *why has the scenario approach been chosen?* – as a way of assessing the impacts of future uncertainties on the flood risk and the flood risk management solutions, taking account of sea level rise, future development, etc. Because the problem is complex, with high levels of irreducible uncertainty and because the approaches to identifying the preferred option require consultation and collaboration between different organisations (and local residents) (thus meet the bullets given in Winterscheid, 2006)

- *what are the expected outcomes?* – an approach that can help determine what is the most robust, sustainable solution for the project in question in a manner that will reduce regret (both in terms of risk and cost). Also to provide an approach that can help address some of the future uncertainties and provide a methodology that can take explicit account of uncertainties
- *what time horizon will the scenarios cover?* – 100 years
- *how much time is available for the scenario project?* – not long! – cannot add significantly to the length of the appraisal process (already too long), needs to become an integral part of the approach building on/into current activities – this is likely to be a key constraint on the application of scenario analysis – how can the issue be overcome – goes back to whether there is a need for overarching scenarios that can be tailored to the local situation – would this be the Foresight scenarios or something else?
- *who will be involved and how much time is required?* – will need to involve project team plus selected local stakeholders (e.g. like group that meets on Dunwich?). They will need to be able to attend most, if not all, of the meetings and provide considerable input to the development and revision of the scenarios and the application of the scenarios to the appraisal. This is likely to require a series of meetings, which will need to be focused. A key issue will be in identifying who are the key people to invite, how many people should be involved (although this may be dictated by time and cost)
- *how much will it cost?* – cannot add significantly to the cost of undertaking appraisal, therefore, needs to be embedded within the approach and, potentially, used in place of something else? The cost has to be proportionate to the decision being made, therefore, the application of scenario analysis may not be required on all projects?
- *how will the scenarios be applied?* – need to be linked to the project goals, have to help identify the most robust and sustainable solution but will probably also need to provide pointers in terms of switching points and where changes to strategy, etc. may have to be made in the future (monitoring). It is essential that the scenarios provide assistance with decision making and help identify a preferred solution – not coming up with a different solution under each scenario.

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Nobel House
17 Smith Square
London SW1P 3JR

www.defra.gov.uk

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