Environmental Risk Assessment And Risk Management

Introduction

- Risk provides the answer to three key questions: what can go wrong; how likely is it; what are the consequences? (Kaplan and Garrick, 1981).

- To this can be added the question: what can be done to manage any risks identified and who should be involved? Environmental Risk Assessment and Management concerns environmental, ecological and human issues and has been an area of rapid growth over the last two decades.

Definitions & Concepts

- Environmental Risk Assessment (ERA) is a generic term for a series of tools and techniques concerned with the structured gathering of available information about environmental risks and then the formation of a judgement about them (DoE 1995, DETR, 2000).

- Risk management involves reaching decisions on a range of options that balance these risks against the cost and benefits (specially including the environmental costs and benefits).

- Communicating the nature and scale of risk and the options is also a key part of the process. Figure 13.1 sketches out the basic elements of a framework within which ERA may be carried out including the options of generic and tailored Quantitative Risk Assessment (QRA).

Environmental Risk Assessment in the context of EIA

- EIA and ERA are very similar concepts in that they broadly have the same goals and are tools that can inform decision-makers about the frequency and magnitude of adverse environmental consequences arising from activities or planned interventions.

- A response to such predictions might be that the manager wishes to mitigate or eliminate a particular impact or reduce the risk (Figure 13.1).

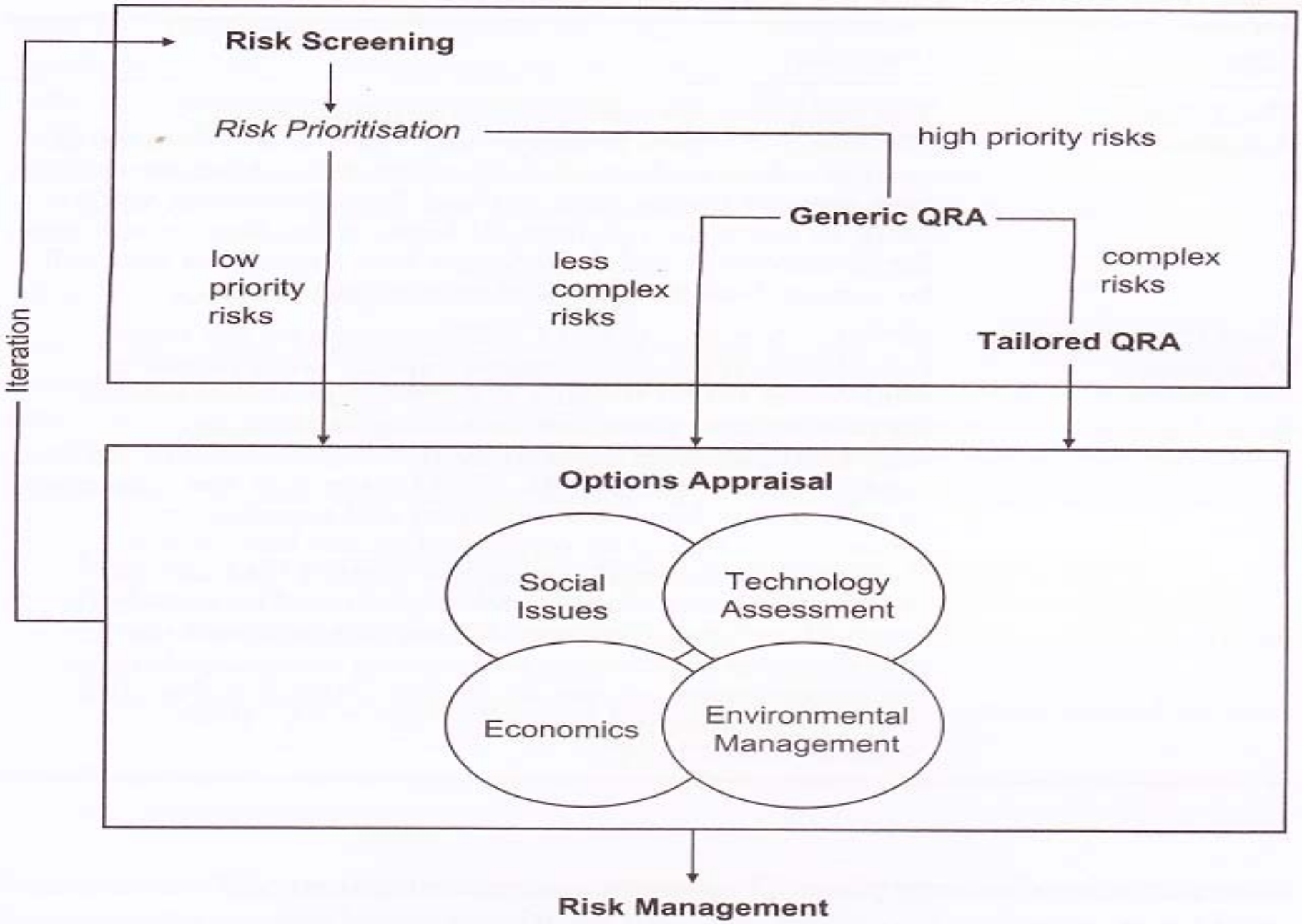

Figure 13.1 A framework for environmental risk assessment.

- A major additional aspect provided by ERA is that it can give probabilities to predicted impacts (Suter, 1993).

- EIA and ERA often overlap and are mutually supportive of each other: they both deal with uncertainty are essentially multifunctional in approach and seek to predict impacts to improve policy, programme, plan and project decision.

- Where potentially negative impacts on the environment and human health must be considered prior to the commencement of a project, they are typically examined through the use of an ERA, ensuring acceptability of site specific risks and hazards.

- ERAs are a legal requirement for activities that potentially cause damage to the environment or to human health. However, the question arises as to when in the planning process ERAs should be carried out.

- Increasingly LPAs have stipulated that they should be submitted at the same time as an EIA and indeed the results integrated to the EIA, with the details of the method appended.

- Examples are detailed in Table 13.1. ERAs can be applied to air quality for example, waste to energy plants), brownfield site redevelopment and contaminated land issues, as well as ecological risks and health risks from new incinerators and industrial processes.

Table 13.1 Examples of risk assessment typically covered in EIA in the UK

Type	*Description*
Flood Risk Assessment	The procedure, set out by the Government in PPS25 (DCLG 2006), aims to avoid inappropriate development in areas at risk from flooding, and to direct development away from areas of highest risk. A Flood Risk Assessment (FRA) needs to assess the risk from all forms of flooding, to and from, the development and demonstrate how these flood risks will be managed taking climate change into account.
Land Contamination Assessment	PPS23 – Annex 2 (DCLG 2004) expands on the policy considerations the Government expects Local Planning Authorities (LPA) to have in regard to preparing policies for development plans and in making decisions on individual planning applications relating to land affected by contamination (see §9.3.4). PPS23 states that the assessment of risks arising from contamination and remediation requirements should be considered on the basis of the current environmental setting, the current land use, and the circumstances of its proposed new use. The underlying approach to identifying and dealing with risk, and the overall policy objective of safeguarding human health and the environment, are similar to that outlined in Part IIA of the Environmental Protection Act (EPA) 1990: "Contaminated Land".

- Trained specialists are typically required to assess risk using a range of software packages, including (in the UK):

  - CLEA (Defra and EA 2002) and SNIFFER (1999, 2003) to model the effects on human health from contaminated soil;
  - ConSim (EA 2003 a) and the Remedial Targets Methodology (EA 2006) for simulating contamination to groundwaters; and
  - RBCA (EA 2003b) to calculate risk levels and/or clean-up standards for soil and groundwater for the purposes of protecting human health and the environment.

Problems with the terminology

- The following definitions employed in this chapter:
  - **Hazard**: a property or situation with the potential to cause harm;
  - **Risk**: a combination of the probability or frequency of the occurrence of a particular hazard and the magnitude of the adverse effects or harm arising to the quality of human health or the environment;
  - **Probability**: the occurrence of a particular event in a given period of time or as one among a number of possible events;
  - **Risk Management**: the process of implementing decisions about accepting or altering risks.

Legislative and policy background

- The Environment Act of 1995 specifically requests local authorities to carry out risk assessment and maintain registers of contaminated land (King, 1998).

- MAFF's (now DETR) Control of Pesticides Regulations (1986) requires environmental risks to be assessed and to some extent the Health and Safety Executive, which is responsible for enforcing legislation on workplace safety, include elements of environmental protection (e.g. Control of Substances Hazardous to Health (COSHH) Regulations, 1994).

- The Habitats Directive (brought into force in the UK by the Conservation (Natural Habitats) Regulations 1994 (Habitat Regulations) has led to licence applications which have referred to risk and uncertainty for species afforded the status European Protected Species (EPS).

Interest groups and sources of information

- In recent years in the UK there has been progress towards harmonizing the approaches to risk assessment advocated or used by Government (e.g. DoE 1995, DETR 2000) and considerable efforts have been made to extend the use and acceptability of ERA.

- Much has been done to promote it as a best practice tool and a principal reason for undertaking risk assessment and risk management is a commitment to sustainable development.

- The Environment Agency, through its National Centre for Risk Analysis and Options Appraisal (EA 1997a) is an example of a specific group that was tasked with the development of tools and techniques,

- However, there are still relatively few ‘how to do it’ manuals for ERA. While it is beneficial to refer to example of practice such as previous EIAs with risk assessments of incinerators or landfill sites at the prescriptive level of EIA for a particular specialism it may be wise to employ a risk specialist.

Key steps in performing an ERA

1. **Hazard identification and analysis**

- The set of hazards to be identified needs to be clearly defined. For a hazard to result in harm there must be a way in which it can affect a receptor.

- An example for a flood defence scheme might be:
  - How likely is it that the scheme will be over-topped with flood water? (Hazard);
  - How might people living on the neighbouring floodplain be exposed? (Pathway); and
  - What effects might be experienced by an exposed individual? (Receptor).

- Identification of the routes by which a hazardous event may occur is exemplified by the example of a lined landfill site with a leachate collection system and an associated treatment plant.

- Since the concern is the escape of leachate to groundwater then it is not adequate to consider only the possibility of the liner being punctured.

- It is equally important to look at the possibility of failure of the leachate treatment plant. Techniques are available for the identification of hazards.

- However, event tree analysis is an accepted means of undertaking hazard analysis. Figure 13.2 shows a typical event tree for an accidental spillage.

- Event trees (also called decision trees) can be relatively simple as in the example shown and it is important not to make them too detailed.

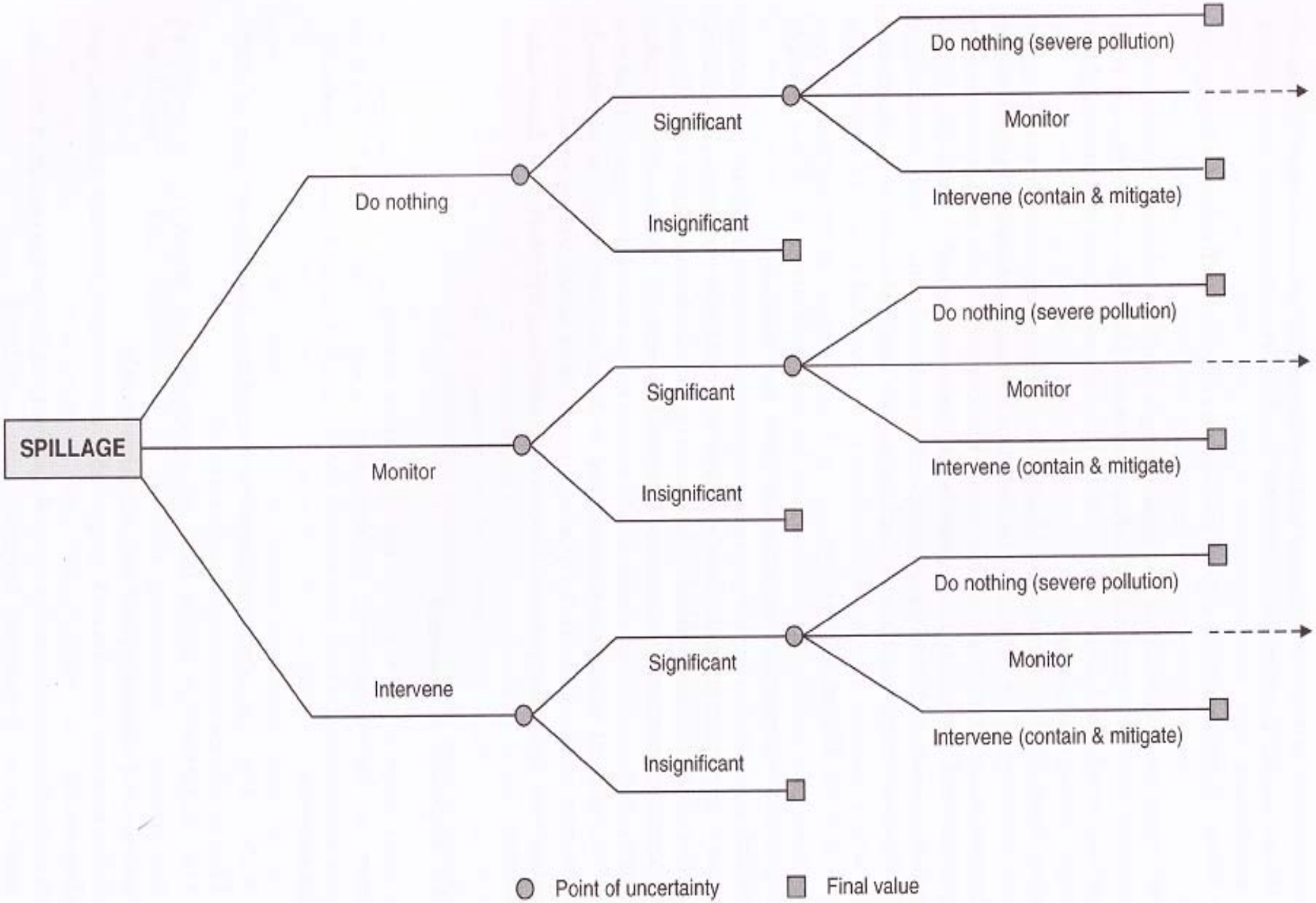

Figure 13.2 An event or decision tree for accidental spillages and pollution risk.

Key steps in performing an ERA

3. Exposure assessment

- Factors to take into account would include:
  - A clear definition of the nature of the hazard (e.g. quantity and the rate of spill). This should be relatively straightforward.
  - The characteristics of the local environment (e.g. sensitivity, presence of rare species). Determining this can be problematic and a detailed site survey over a considerable area could be costly.

- Behaviour of the hazard (e.g. infiltration rates, stream dilution, air dispersion).
- Specific ‘dose response’ relationships that might be known for particular species or environmental features being considered.

- Determining the first factor is a relatively straightforward process but the remaining three are much more difficult and complex and demonstrate some of the difficulties surrounding environmental risk assessment.

- Table 13.2 lists some descriptors that might be used to indicate various levels of consequence.

Table 13.2 Examples of risk consequences

Type of consequence	Description
Very high risk	Ecosystem irreversibly altered; no recovery. Over 100 km^2 affected.
High risk	Ecosystem altered, but not irreversibly; recovery may take as long as 50 years. 50-100 km^2 affected.
Moderate risk	Only one component of the ecosystem affected; 10 year recovery period.
Low risk	Temporary alteration; effects confined to less than 0.5 km^2; recovery in less than five years.
Very low risk	Temporary alteration; very localized and minor consequences.

Key steps in performing an ERA

3. Risk estimation

- Risk can be determined by combining the results of hazard and consequence analyses and the simplest form of risk estimation is matrix (Table 13.3).

- Such matrices can be designed to be as simple or as complex as appropriate. Approaches to completing a matrix can be qualitative, quantitative or a combination of both.

Table 13.3 Simplified risk matrix

Probability or likehood	Magnitude High	Medium	Low
High	Very high risk	High risk	Moderate risk
Medium	High risk	Moderate risk	Low risk
Low	Moderate risk	Low risk	Very low risk

- More complex (and perhaps more controversial) approaches include the use of multi-criteria analysis (MCA) which can involve ranking, scoring and weighting methods to attain an overall risk score.

- Such methods have now been successfully used to examine risks due to genetically modified organisms (DoE 1995) and road transport (EA 1997b).

Key steps in performing an ERA

4. Risk evaluation/options appraisal

- The importance of this step is in the judgement of the acceptability of the risk.

- In terms of human health this risk might be expressed in terms of the number of additional deaths per million people arising from a lifetime of exposure or the probability of the frequency of events causing fatalities.

- From an environmental perspective the preferred option is likely to be the one with the lowest risk. However risk acceptability depends on a complex set of psychological factors.

- The communication of the ERA results can take the form of an Options Appraisal, i.e. for each option what are the risks, cost and benefits?

- This can also be useful in authoring the ‘Alternatives’ chapter in an Environmental Impact Statement (EIS). Effective communication can change a layperson’s pre-conceived assessment of risks. This leads to more rational decision-making based less on emotions.

Key steps in performing an ERA

5. Risk Management

- Risk Management uses the results of ERA to mitigate or eliminate unacceptable risks. However, important to consider whether or not a particular Risk Management measure leads to a secondary consequence.

- It is also important to ensure that the appropriate level of resource is directed to the level of risk reduction warranted in a particular circumstances.

- It is clearly not sensible to direct huge funds at a minor risk. There is a clear need to iterate between Risk Management and Hazard Analysis.

- Table 13.4 lists the types of options that could be evaluated in relation to road transport and the environment (EA 1997b).

Table 13.4 Risk Management options that might be addressed in consideration of road transport impacts on the environment

Type of option	Examples of Risk Management
Policy level	Developing a multi-modal approach to transport, e.g. consideration of investment in forms of transport other than roads.
programme	Consideration of the roads programme for the whole country: rejecting schemes at an early stage with the potential for significant environment impact.
Plan	Integrating land use and transport plans, e.g. to consider options for reducing traffic congestion in urban areas.

Table 13.4 Risk Management options that might be addressed in consideration of road transport impacts on the environment

Type of option	Examples of Risk Management
Project level	Improved road design for minimising environmental impact: noise reduction using newer types of surface; improved safety.
Technology	New technology fitted to cars to reduce emissions; using techniques for the secondary treatment of road runoff to remove sediments and other pollutants.
Economic	Mechanisms for charging for road use (e.g. in selected city areas; increased taxation on fuel etc.
Education	Improved driver training to minimise accidents but also to instruct the relevant services of what to do in an emergency situation to minimise pollution to the environment.

Different levels of ERA

- The different levels of risk assessment can be described as follows (EA 1997a)

  - **Risk Screening** – the process used to determine the range of risks and the factors that control whether they will result in environmental damage. It can be based on available data and substantially on professional judgement.

  - **Risk Prioritisation** – a step used to describe the most important risks. If it is decided to progress further with analysis, then monies can be invested in these key risks rather than looking in detail at all risks.

- **Generic Quantitative Risk Assessment** – the use of generally available and tested models to provide simple quantification of the risks.

- **Tailored Quantitative Risk Assessment** – the development of specific models to meet a particular purpose. This is usually complex and costly (e.g. for disposal of radioactive waste).

- Figure 13.3 shows the different levels of sophistication that might be used with increasing risk and cost. It is important to adopt the most appropriate techniques to suit the issue under consideration.

- A global problem such as the depletion of the ozone layer is likely to require a different approach to remediation of an old gas works site for housing development.

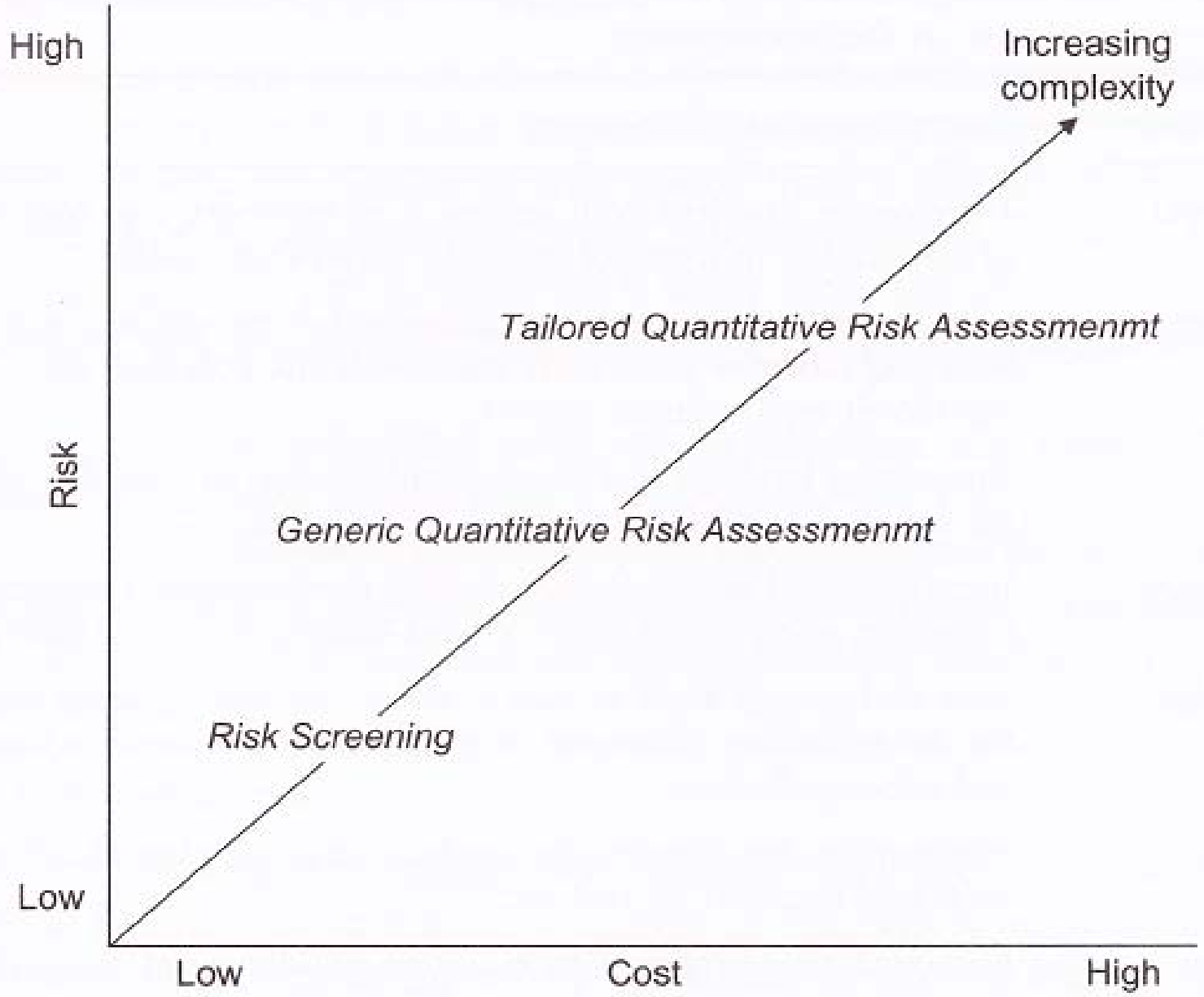

Figure 13.3 Levels of sophistication that might be used with increasing risk and cost.

Parallels between EIA and ERA

- Both EIA and ERA are structured tool leading to recommendations concerning the environment that can assist decision makers.

- While there are clear parallels to be drawn there are also fundamental differences: for example EIA typically involves consideration of development alternatives while ERA does not.

- Both are essentially iterative processes and it is important that as a final stage after implementation of a project, monitoring and audit be considered (Table 13.5).

Table 13.5 Comparison between EIA and ERA

Framework for EIA	Framework for ERA
Screening of the project or proposal and preliminary assessment of the existing environment to decide whether to carry out a full blown EIA followed by scoping of the key environmental issues likely to be affected by the project or proposal.	Screening to determine the range of risks, and the factors that control whether they are likely to result in damage to the environment. When all risks have been identified **prioritization** or ranking is conducted to ensure that resources for further work are targeted at the highest priority risks. Defining the problem is also known as **hazard identification**.
Baseline Studies – collection of existing information.	

Table 13.5 Comparison between EIA and ERA

Framework for EIA	Framework for ERA
Impact Prediction – determining the magnitude, spatial extent and probability of impacts, including direct and indirect effects.	**Hazard Analysis** involves identification of routes by which hazardous events could occur and estimation of the probability or chance of occurrence. **Consequence Analysis** involves determining the potential consequences of a hazard. **Risk Determination** combines the results of hazard and consequence analysis.
Assessment of the relative importance of the predicted effects, taking into account the present condition and the future condition that would result, as well as any measures of mitigation.	Judging the significance of the estimated risk is known as **Risk Evaluation**, i.e. whether the environment is likely to withstand the effects.

Table 13.5 Comparison between EIA and ERA

Framework for EIA	Framework for ERA
Evaluation of the overall acceptability of the proposal or project and each of its alternatives, leading to selection of one or more preferred options.	It may well be right for decision to be taken partly in response to pressures generated by risk perceptions. **Risk management** options may be concerned with tolerating or altering risks.
Monitoring and audit e.g. leading to confirmation or rejection of predicted effects.	**Monitoring and audit**. Confirmation or rejection of predicted effects.

Opportunities and challenges for ERA

- Some factors leading to uncertainty in ERA are:
  - Ecosystems are open, dynamic and complex systems with ‘built-in’ variability and recoverability.
  - Individual sub systems may be interdependent.
  - Adjustment to, or recovery from, particular impacts may be over a time span longer than a human life.
  - It is inherently difficult to measure causal relationships.
  - Release of certain persistent materials may cause irreversible change.

- Synergistic effects may arise, e.g. when two chemical pollutants interact and the combined effect is greater than the sum of their separate effects.
- Perceived risk may be just as important (if not more so) than real risk.

- The relationship of risk assessment with UK Government guidelines on the precautionary principle is discussed in ILGRA (2002).

- Possible uncertainty scenario are illustrated in Figure 13.4.

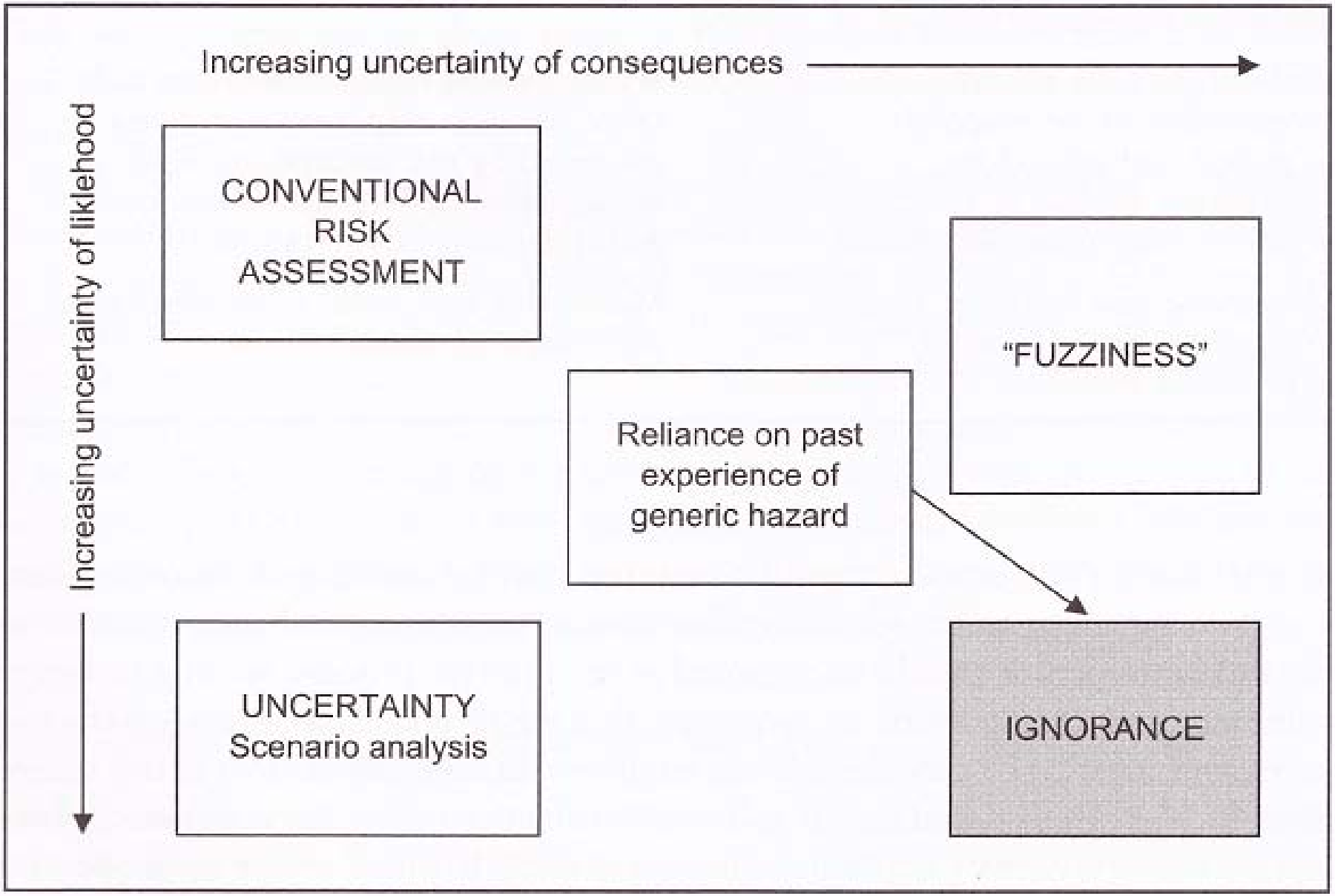

Figure 13.4 Risk, uncertainty and ignorance (adapted from ILGRA 2002).

Issues for EIA/ERA cross fertilisation

Issue	EIA	ERA
Objective process	Development needed: EIS reviews often give a high score to grammatical and procedural elements of a report rather than objectively assessing technical credibility.	Considerable experience: although not professing to be a very objective process, scientific information is considered systematically.
Recognition of uncertainties	Further development needed: many EISs profess that 'all will be well' and/or contain unqualified statements about the effectiveness of new technologies for mitigation.	Considerable experience: consideration of uncertainty is fundamental to risk assessment.

Issues for EIA/ERA cross fertilisation

Issue	EIA	ERA
Consideration of alternative	Considerable experience: implicit that development alternatives are considered early in the process.	Further development needed: more emphasis could be given to consideration of alternatives early in the process.
Public involvement	Further development needed: calls for public participation in the EIA process.	Considerable experience: much literature on the value of and procedures for, evaluating risk perception and communicating risk.
Strategic level of appraisal	Considerable experience: theory and now considerable practice of the Strategic Environmental Assessment (SEA) process at policy, programme and plan levels.	Development needed: much potential to translate what has been learned in SEA to Strategic ERA, e.g. in recent years, Strategic Flood Risk Assessment (SFRAs) have been undertaken.