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Strategic risk assessment—prioritising environmental protection

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Abstract

Environmental protection and improvement comes at a price, and regulators must ensure that resources are targeted at the highest priority risks. Risk assessment at a strategic level is now an essential tool. Risks can arise from natural sources such as flooding and radon, as well as anthropogenic sources such as discharges of pollutants or the introduction of alien fish species. In deciding which environmental pressure to tackle next, and which to leave, regulators have to compare the full range of risks on a sound and consistent basis. *Comparing risks* from such diverse sources poses a significant challenge and traditional hazard assessments are now no longer sufficient. Consideration now needs to be given to a much wider range of factors if risk assessment is to be used as an aid to strategic decision-making. In general, Strategic Risk Assessment can be broken down into four main tasks. (i) *Harm assessment*—where the impact of a given level of exposure on a predefined receptor group is determined. (ii) *Risk* significance—where the harm evaluated in (i) is placed in the *geographical* (*regional, national, international*) *context* in relation to the overall population of receptors, and the range of different receptors. (iii) *Risk uncertainty*—where the probability of occurrence, exposure and harm is quantified together with the range of uncertainties involved in the overall assessment. (iv) *Risk importance*—where the *costs and benefits* of various actions/options together with a measure of society's view of the risk are brought together. All the above have been included in the Strategic Risk Assessment Methodology which has been developed by the Environment Agency, and will be used to direct the organisation's manpower and financial resources to maximise its contribution to sustainable development. © 1998 Published by Elsevier Science B.V. All rights reserved.

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1. Introduction

In many countries, the regulation and management of the environment is a key public sector activity. Awareness of environmental issues has grown significantly since the Rio Earth Summit in 1992, and is increasingly a key aspect of Government decision making.

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However, few major advances have been made in ensuring that decisions regarding the future of our environment take into account the wider aspects of risk assessment and economic appraisal.

The Environment Agency in England and Wales has a principal aim, set in statute, to contribute to the objective of sustainable development. The Government has set out statutory guidance on how this aim should be delivered, and in doing so, makes reference to a range of objectives, tools and methods, of which the following are of relevance here:

- decisions should be based on best scientific information and an analysis of the environment and the factors that affect it;
- the Agency should take an holistic view of the environment; and
- tools such as risk assessment, policy appraisal and economic appraisal should be used to help the Agency in its decision making.

Risk assessment is therefore seen as a key technique in the future protection and management of the environment in England and Wales. In addition, it should be integrated across environmental media (the holistic view), over long timescales (in view of sustainable development), include an assessment of the needs and views of society, and be integrated with the best scientific information available.

Given the level of public understanding of concepts such as risk, environmental benefit and sustainable development, the terminology and approaches adopted in traditional hazard assessments are clearly limited in application in this new field.

The Department of the Environment [1] set out a broad framework for risk assessment and risk management for environmental protection. This framework set out a logical procedure by which risks are first screened and then assessed, with the latter stage including some consideration of risk perception. In an earlier guide, Department of the Environment [2] established rules for the economic and environmental appraisal of projects. Seen together these documents provide a useful place from which to develop a working tool.

Since the framework set out in Department of the Environment [1], issues such as Brent Spar, BSE, and increased pressure on road transport have highlighted the fallibility of scientific assessments of risks undertaken in the absence of the more strategic framework. Whilst decisions may be based on the best scientific information available, due consideration now needs to be given to a much wider range of issues if the priority assigned to a given risk, and by inference the immediacy and weight of any resultant action by the regulator, is to be credible.

The following sections set out the development of the SRA methodology by the Environment Agency in England and Wales.

2. Experimental

2.1. The overall structure

In developing the SRA methodology, the Agency has sought to ensure that it is as transparent and logical as possible. Through this approach it is hoped that the public's

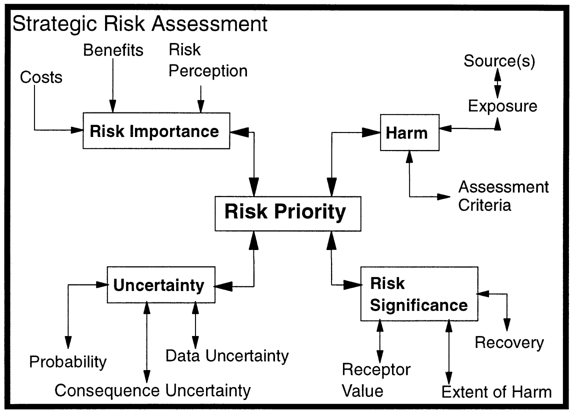

Fig. 1. The SRA methodology by the Environment Agency in England and Wales.

understanding of risk assessment will be improved and their trust in decisions made on information generated by the method will be greater (see Fig. 1).

Taking this into consideration, the overall SRA methodology is based around the following principles.

2.1.1. Harm assessment

Where the impact of a given level of exposure on a predefined receptor group is determined, and is normalised in relation to an predetermined and publicly-known standard or target.

2.1.2. Risk significance

Where the harm evaluated in Section 2.1.1 is placed in the *geographical* (*regional, national, international*) *context* in relation to the overall population of receptors, and the range of different receptors affected.

2.1.3. Risk uncertainty

Where the probability of occurrence, exposure and harm is quantified together with the range of uncertainties involved in the overall assessment.

2.1.4. Risk importance

Where the *costs and benefits* of various actions/options together with a measure of society's view of the risk are brought together.

Each of these areas are now described in a little more detail.

2.2. Harm assessment

The assessment of harm to a given receptor group represents the traditional scientific assessment of risk. It has deliberately been taken away from a hazard assessment in light of the fact that society may not recognise some of the longer-term chronic impacts as hazardous in the more catastrophic sense of the word.

In dealing with sources of risks as diverse as overtopping of flood defences, disposal of radioactive material, the emission of NO_x from a power station or the discharge of Cd from a sewage treatment works, the key element in the harm assessment is normalisation. The potential for poor intercomparison of risks from unrelated sources is considerable, and could render the assessment irrelevant.

The key stages within the harm assessment are:
- quantifying the sources of the risks,
- quantifying the exposure arising from the sources,
- setting the assessment criteria,
- assessing the harm and normalising this against the assessment criteria.

In the context of the SRA model, Monte Carlo or latin hypercube simulation methods through the use of tools such as Crystal Ball or @Risk as described by Vose [3] are sufficient for this level of harm assessment.

The assessment criteria used in this process are recognised standards or targets as set down by the European Commission or the UK Government. This ensures that the yardstick by which the severity of the risk is to be measured is already well accepted by the public.

2.3. Risk significance

Many environmental risk assessments are site-specific, and concentrate on the potential to cause environmental damage at the local level. However, much of what attracts the public's attention, and by default alters commercial and political views, takes place on the regional, national or international level. It is, therefore, important that the significance of the scientific assessment of risk be placed in a wider context.

The key factors that were considered to be important in establishing the wider significance of risk were:
- the spatial extent of which the harm may be expected,
- the time over which harm may be expected,
- the time over which the receptor population may recover naturally,
- the number of other receptors that may be affected.

2.4. Uncertainty

By their very nature, risk assessments are undertaken in areas where there are likely to be great uncertainty. However, to the public, uncertainty can often equate to inability to manage or unwillingness to manage the environment. Indeed, Kass and Norton [4] have shown that public trust in information put over by Government is generally low. This is exemplified by Fig. 2 from Ref. [5]. One of the factors known to be important in this lack of trust, is the public's perception that the regulator is unwilling to admit to the uncertainties in information, knowledge or the environment.

As an issue, uncertainty is likely to be amongst the most difficult of the concepts for society to understand. Vose [3] identifies two principal components of uncertainty, namely: (i) the inherent uncertainty of a variable, and (ii) the uncertainty arising from

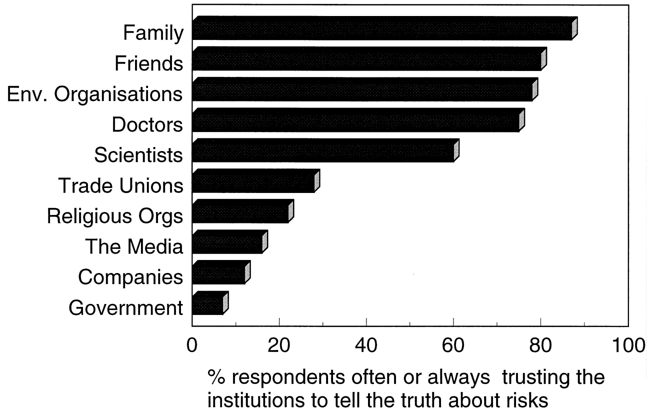

Fig. 2. Trust of respondents in different situations.

the expert's knowledge of the variable. In reality, these may be further split into the following:

- the probability that the source of the risk will lead to the harm predicted,
- the inherent variability in the environment,
- lack of knowledge of the environmental impacts of certain sources of risks,
- inadequate data and/or information regarding the risk scenario in question.

These factors have to be quantified in terms of the confidence the regulator has that the best scientific information has reduced such uncertainties to a tolerable level. Techniques such as sensitivity analysis can be used to determine how relevant a given uncertainty may be in relation to the final outcome, whilst Bayesian statistics can be used to reduce uncertainties of existing data.

2.5. Risk importance

The final component of the SRA method concerns the importance placed on any risk of environmental damage by various sectors of society. There is evidently a key link here with both risk communication and risk perception, yet it is also an area where quantification of the key attributes will continue to cause the regulator some difficulties.

The key factors that were considered to be essential in this area were:

- the costs to industry/society of preventing the risk of environmental damage,
- the costs to the environment of allowing the environmental damage to occur,
- the public's perception of the risks, impacts, and costs,
- the political view of the risks, impacts and costs,
- the scientific view of the risks and impacts.

Experience of issues such as Brent Spar has highlighted the differing opinions held by the public, politicians and scientists. Each stakeholder group has a valid opinion, and all have to be accommodated in the overall assessment of risk.

The field of environmental valuation is a developing one, and the robustness of many of the techniques is open to question. Toman et al. [6] set out the basic theory of environmental valuation in the context of sustainability, intergenerational equity and natural capital; all such factors have to be taken into account in valuing the environmental side of the equation.

2.6. Risk priority

In light of the above, the true assessment of risk may be inferred from the following:

$$\text{Risk Priority} = (a \times \text{Harm}) \times (b \times \text{Risk Significance}) \times (c \times \text{Uncertainty}) \times (d \times \text{Risk Importance})$$

where factors a, b, c and d are weightings applied by the regulator.

It is clear to many in the risk field, that probabilities or frequencies are very poor in conveying the true scale of a risk to an audience which is often very uninformed. Scientists are often reluctant to relegate detailed calculations to a simplistic level, it is essential to do just this in areas where comparisons of diverse risks are required.

The Risk Priority is therefore expressed in terms of the following scale.

Colour	Priority of Risk	Risk Scoring
Red	High priority	75–100
Amber	Medium priority	50–75
Green	Low priority	25–50
Blue	Negligible	0–25

3. Results and discussion

3.1. The model

The Environment Agency has a legal duty to investigate the use of risk assessment techniques at all levels in its decision making process. The SRA method and related model are in the early stages of development and trial. At present they are being tested on a broad range of environmental issues in the south-west of England, and on the more emotive and nationwide issue of the impact of road transport on the environment.

The SRA model has been developed using Crystal Ball as a basis. This has proved necessary in order to accommodate predictions of uncertainty, and to enable probability distributions to be modelled alongside more certain information. This model also provides for scenarios to be assessed very quickly, and for the sensitivity of the final risk priority to certain input variables to be determined.

3.2. Assessment criteria

It is clear from the early testing of the SRA model that the normalisation of the harm is a key step. Selecting the wrong standard will have severe consequences for the final Risk Priority. One of the significant drawbacks in any comparative risk assessment is the paucity of accepted standards across all three media. In the UK for example, standards exist for less than four chemical substances across air, land and water. Even where standards exist, their risk basis can often be questioned as safety factors translating scientific fact such as EC_{50} into environmental standards may be arbitrary to say the least.

However, in other areas such as where the standards are set to defend different land use types against flooding, assessing and subsequently normalising harm is relatively straightforward.

3.3. Societal perception

In its current testing, the method appears to provide a sensible ranking of risks from disparate sources. However, the key constraining factor is societal perception and this has to be monitored carefully. The Comparative Risk Assessment technique piloted by the USEPA has been constrained by the need to consult a wide range of experts and interested parties during the process. The SRA method relies on a smaller sample of stakeholder groups through which to establish the societal issues involved. The Agency is overseen on a day-to-day basis by 24 Regional Committees the composition of each of which spans all major stakeholder groups. This provides a useful quick route to assess public opinion.

At present, it is clear that the weighting applied to the Risk Importance element of the SRA method is a key aspect, due to the sensitivity of the result to the societal perception.

4. Conclusions

The need to consider risk at the strategic level is now well accepted. The public expect large environmental organisations and regulators in particular to focus their resources on the most significant risks of environmental damage. This is clearly only possible if an SRA method can be developed which takes in the wider socio-economic issues alongside the traditional elements of risk assessment. In addition, the public will only trust regulatory decisions if the decision making process is credible and transparent. The SRA method is an attempt to improve public confidence in the use of risk assessment in decision making.

In the future, the SRA method will be refined to enable the Agency to establish corporate priorities based on a fuller appreciation for the risks facing the environment.

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