A Proposed Research Agenda for Incorporating Risk Analysis in Environmental and Social Impact Assessment

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FOREWORD

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SUMMARY

The development and utilization of risk analysis concepts and methodologies has the potential to significantly improve the environmental impact assessment in Canada. Currently risk analysis is not a common tool of environmental decisionmakers and greater effort is required to make it more accessible. However, the successful integrations of these two processes will require a concerted effort in a number of areas. The purpose of this report is to identify some of the higher priority research needs.

One of the major areas requiring research is in the development of protocols for the use of risk analysis in environmental impact assessment and the interpretation of the results. The methodologies developed must be utilizable or at least understood by persons not experienced in quantitative risk analysis.

Perception of risk by the public and experts is a major factor in RA. Study is needed into the best way to communicate risks in general. Research also is needed on the cognitive processes of both groups to ensure that a proper treatment of perceived risk occurs in the RA procedure.

The way in which risk is communicated to the public can be a significant factor in the way in which the risk is perceived. Research is needed to transform the results of technical RA into a forrn which can be understood by nOn-experts. Study is also needed into the best way to communicate risks in general.

Practical considerations for the incorporation of risk analysis and environmental impact assessment could be examined through case studies. These studies would also serve to demonstrate the relevance and usefulness of this approach.

Techniques for the mitigation of risk and resolution of conflicts arising frorn environmental disputes need further study to assess their utility in practical applications.

Since a multi-disciplinary approach is required for both EIA and RA, Training and education is needed to ensure that experts from various disciplines can work together in the multi-disciplinary approach required in both risk analysis and environmental impact assessment. This is particulary true for RA, which has not had great exposure for persons working outside of engineering and other technical or mathematical disciplines.

INTRODUCTION

Environmental impact assessment (EIA) is increasingly being considered as a major component of the planning process which takes account of the ecological and social implications of proposed development activities. Although EIA originated as a narrowly-focused, procedural step in the approval of specific projects, it has since grown into an integral part of a more comprehensive management process. In general, it has dealt with impacts or consequences that are deterministic or certain, although some EIAs have dealt with uncertain impacts as well.

It has been suggested (Maclaren and Whitney, 1985) that EIA is currently in a crucial stage of its development. One direction that it may take is for the EIA procedures to be continued to be viewed as a set of regulatory hurdles that proponents have to overcome in order to obtain permission for the implementation of a project. This approach does not include any follow-up to evaluate the EIA predictions. An alternative direction is for EIA to adhere firmly to the scientific methodology path of problem and hypothesis formulation, hypothesis testing and the analysis of results, and modification or reformulation of the original hypothesis.

The Canadian Environmental Assessment Research Council (CEARC) was founded to "advise on ways to improve the scientific, technical and procedural basis for EIA". Research on improvements in the concept and practice of EIA can take many forms, but "should be directed towards increasing our understanding of the environmental and social consequences of development, and towards improving our ability to forecast and manage effects of development to meet the stated social goals".

One of the major areas identified by CEARC by which EIA could be improved and to meet the above objectives is to be found in risk analysis and the management of uncertainty. Although similar to EIA, risk analysis (RA) differs in that it deals with impacts that contain uncertainty. This uncertainty may be about whether the impacts will occur or not; or if they do occur, the uncertainty concerns their spatial and temporal occurrence, and to who or what will be impacted.

A general summary and perspective on RA and EIA is found in the CEARC-sponsored study by Grima et al. (1986). This work

has identified some high-priority research needs. CEARC sponsored the current study to develop a specific research agenda pertaining to the role of RA in EIA.

In this report the research needs are categorized in seven broad areas:

- Procedures
- Data
- Risk Perception
- Risk communication
- Case Studies
- Mitigation of Risk
- Training

This study was conducted by a survey of the literature, CEARC-sponsered work, and by a review of the perceived research needs by a number of faculty members of the Institute for Risk Research at the University of Waterloo. Persons participating in the study were M.E. Haight (Urban and Regional Planning), K.W. Hipel (Systems Design Engineering), S.C. Lerner (Environment and Resource Studies), N.C. Lind (Civil Engineering), R. Keith (Environment and Resource Studies), and R.C. Suffling (Urban and Regional Planning).

1. PROCEDURES

The incorporation of RA into the EIA process requires a number of research efforts designed to develop new RA methodologies, to aid in the interpretation of the results of RA, and to integrate the two processes. These research needs include:

1.1 Risk assessment, while purporting to include aspects related to the implementation phases rarely if ever extends beyond the pre-decision/decision phases. Thus research efforts need to be initiated that would allow for the process to extend to the very important phases of project development (implementation) and then project operation. These efforts would serve to:

a) substantiate the predictions and assumptions made initially

b) determine if the risks shift to a more or less higher level or remain as predicted

1.2 Traditionally, EIA has tended to emphasize the impacts on ecosystems, while RA has emphasized human health effects. This difference in target effects has no basis in analytical methodologies, but reflects the administrative or scientific/professional communities associated with each. Therefore both EIA and RA would be improved by eliminating such differences, especially by utilization of RA to predict environmental consequences (see section 1.4).

1.3 There is a need to develop guidelines for the acceptability of risk i.e. at what point should the probability of an adverse event be considered to be unacceptable? For example Beanlands (1986) found that a *review* of EARP panel reports suggests that their advice to decision makers is more influenced by their perception of the consequences of the event rather than the probability. This therefore suggests that beyond some level of probability the arguments over probability are mainly academic.

1.4 A greater integration of ecology into the EIA process and the need to improve the capability of predicting ecological change was identified by Beanlands and Duinker (1983) and Beanlands (1985). Logically, it follows that there is a need to adapt RA for use in an ecological context. Suter et al. (1986) suggests that most of the operational risk analysis

methodologies already exist (e.g. air/water quality models, ecological effects models, toxicological data bases) and that the only constraints on the usefulness of existing models and data are that:

a) the models must be modified such that the results can be expressed in probabilistic terms

b) error variances in experimental studies and in data extrapolation5 must be reported so that parameter uncertainties can be quantified

Ecological risk assessment has evolved to the point that Barnthouse and Suter(1986)have assembled a "User's Manual for Ecological Risk Assessment". Although their risk assessment concepts were intended to be used for synfuels technologies, they did identify four items of research that are needed:

a) better understanding of the chronic effects of toxic chemicals

b) more information on the effects of contaminants On invertebrates

c) standardization of toxicity text systems for aquatic and terrestrial plants

d) validation of ecological risk models.

1.5 Persons faced with incorporating RA into EIA need access to commonly accepted protocols which need to be sufficiently generic to be applicable to a range of projects and specific enough to provide substantial guidance. Currently, EIA is conducted by people with little practical knowledge of RA, and hence, little perception of how the process could be incorporated.

1.6 The strengths and limitations of RA need to be documented to provide information for persons interpreting the results. As outlined in section 1.5, these persons are often unfamilar with the quantitative methodology of RA.

1.7 Research is required to assess the potential capability of both RA and EIA to predict cumulative effects in an environment which is receiving a number of perturbations from a variety of sources. Although this pattern occurs in most environments, cumulative effects have rarely been examined (Vlachos, 1985; CEARC and NRC, 1986).

1.8 Dooley (1985) suggested that the appropriate baseline for RA is the risk profile for the segment at risk and for society as a whole. Therefore, the impact of a specific risk can be evaluated by examining the net impact on the risk profile. However before an adequate risk profile can be developed, two major information gaps must be filled:

a) the development of appropriate measurements of risk so that comparisons can be made

b) the development of an adequate risk classification system so that proper accounting of risks can be made

1.9 The need to investigate the appropriateness of including economic risks and benefits of proposed projects in the EIA process in a more comparative and integratiue way than has been conducted in the past was discussed by Grima et al. (1986). The proponent is likely to be capable of examining the economic risks and benefits of any proposed project. The economic risk imposed on any potentially adversely affected communities should also be studied in terms of mitigating measures, compensation and insurance. The problems of comparing economic risk with other risks, in particular health risk, needs to be studied.

1.10 The importance of scenario building (particularly worst-case analysis) as a method of prediction needs to be examined further. Research into the risks and impacts of low-probabilty high-consequence events is particularly relevant to EIA. Risk analysis often deals with worst-case analysis, which may or may not be an waste of valuble time and resources. A more practical alternative may be a "worst-plausible-case analysis, which would focus attention on serious areas of concern. This kind of scenario building would be an excellent way to enable the public to usefully express its concern about future impacts. Research in this area should include worst-case analysis and worst-plausible-case analysis in terms of minimum requirements of technical information, understanding by non-specialists and the potential contribution of the interested public (Grima et al., 1986).

1.11 A protocol or methodology for scenario construction is required if scenario-building is to be a useful component of RA and EIA. The techniques available leave wide room for expert judgement and intuition, and since there are no rigorous criteria for the quality of scenarios, the, cognitive processes involved operate under marked uncertainty (Jungerman, 1985).

1.12 Modelling and simulation are often used in EIA and are of use in RA in well. However as discussed by de Broissia (1986) the credibility of models in general must be increased to increase utility. This could be done by validation of impacts predicted by past studies and follow-up of the projects with monitoring effects, organization of comparisons between physical and mathematical models, and by comparisons of different models used for similar purposes.

2. DATA

Any modelling process is only as reliable as the input data. The development of RA in particular has been hampered by a paucity of adequate data bases and information. The development of these data bases has, in turn, been hindered by a lack of clear insight as to the exact nature of the information required.

Research needs for the development and utilization of data include:

2.1 A major challenge for the successful incorporation of RA into the EIA process *is* the treatment of subjective data. This data, whether generated by experts or the public, reflects a statement of concern, preference, judgement, or opinion. Although current EIA procedures do have some capacity to deal with subjective data, no such capacity exists in risk analysis. Therefore a research effort is needed to develop protocols for the inclusion of such data in RA.

2.2 Data are needed in a form that can serve as baseline reference for a projects risk. This requires a classification of hazards and risks, suitable organized in a data base, *with* disaggregation according to occupation, social class, geographic regions of Canada, etc. The data structure has to match the classifiction of events in the RA. The means to establish this compatibility should be investigated.

2.3 Acceptable protocols are needed for developing specific data (needed in the analysis of a project from generic kinds (e.g. worldwide statistics).

2.4 Dooley (1986) stated that an ideal system for RA would have the support of a number of information systems. A baseline data system for impacts and a risk profile system for risks are two of these needed. These **are needed so that the various actors can have access to a common base against** which to compare projects, programs and activities.

2.5 Guidelines for RA in EIA need to include protocols an the assessment of the adequacey of the data and the scientific understanding. RA is of ten compromised by information generated for other purposes, differences in available data, and the need to extrapolate beyond the range of available data. Research into this area is needed to examine case studies, provide examples, and to explore further the problems of information quality (Grima et al., 1986).

3. RISK PERCEPTION

The rising concern of the public about health and environmental risks has led to the production of a substantial body of knowledge on public risk perception. This data, generated primarily in the social and behavioral sciences, can play a vital role in environmental and risk decision processes (Covello, 1985). To date however, this data has had few practical applications and as outlined by Covello, "if progress is to be made toward the common goal of better understanding, better policy, and better protection of public health and safety, all parties need to make a serious effort to incorporate social and behavioral research on risk in policy formulation and risk management decisionmaking".

Research needs to incorporate public perception in the RA and EIA process include:

3.1 The difference between the decisionmakers risk (resulting from RA) and risks as perceived by the public has important consequences for environmental decisionmaking. Research must be conducted to develop procedures so that the risks perceived by the public are incorporated into RA. Instead of merely the experts being involved, the process must be "humanized" so that the technical complexity is reduced for the public to understand. The process must be modified so that the public can be integrated directly into the process.

3.2 In applying risk assessment procedures, it is common for public participation to occur after the experts have identified the potential hazards and determined the possible risks, Expansions of the participatory elements as is commonly applied in EIA, may need to be included throughout the entire process. This would include the initial steps of scoping out the areas to be analyzed, as well as assisting with analyses, decision making, and implementation stages. It may be further desirable to develop an RA procedure which could be used to predict perceived risk. This may follow an outline by Covello (1985) of the factors involved in the public perception of risk.

3.3 Research is needed into the presentation of technical information on risks to non-experts One of the more significant limitations of incorporating RA techniques into RA is the mathematical nature of much of risk analysis. As outlined by Beanlands (1986) RA quickly becomes a topic for

discussion among risk experts with little or no input from the public, due to the complexity of the procedure. However the presentation of the results of RA to the public is critical in developing public understanding of the strengths and limitations of analytical techniques of RA.

3.4 Grima et al. (1986) suggested that the next full scale EIA should have associated with it a social research component which would document the various expressions of risk strategies on the part of experts, scientists, project proponents, and the public. Owing to the complex nature of risk perception, it is vital social science be incorporated into the risk assessment process.

3.5 Generally public-perceived risk focuses on the worst case scenario regardless of its likelihood. Scientists or other experts however, often focus on the perceived likelihood of adverse effects as being very small, and thus disregard the consequences. Research is needed on how such an orientiation can be normalized so that a rational and defensible environmental decision process will result.

3.6 In their discussion on the structure of expert and lay perception of risk, Slouic et al. (1985) stated that although it is assumed that the public has difficulty in judging risks accurately, there is no assurance that experts' judgements are immune to biases once they are forced to go beyond their precise knowledge and rely upon their judgement. Research is needed to determine how perceived risk of experts affects the RA and EIA process.

3.7 Vlek et al. (1985) outlined the need for psychological reseach on the perception of judqement and risks. This would serve to document the relationship between perceived risk and its connection with expected value.

4. RISK COMMUNICATION

The way in which the public perceives a risk is strongly influenced by the manner in which the risk was communicated.

Research requirements for the improved communcation of risk include:

4.1. One reason for the gap between analyzed and perceived risk is that the analyzed risk has not been well communicated to the public. Research is needed to develop believable and understandable scientific procedures to compare risks from different alternatives.

4.2 A possible means to aid communication of environmental or health risks to the public would be the development of a risk scale similar to a "Mercalli Scale" or "Mohs Hardness Scale" which would relate the projects risks to a set of standard reference risks.

4.3 Earle and Cvetovich (1985) stated the need for studies for the clarification of the role of scientific hazard information in the development in the development of public and expert risk judgements. This includes the role of the media, scientific writers, etc. in characterizinq and detailing this information.

4.4 Despite a high concern by the public about the risks from the impacts of technological developments, little progress has been made towards providing the public with usable information about such risks. In part this is due to differing scientific opinions about the nature and magnitude of the risks. As outlined by Hammond et al. (1985), the judgement and characterization of risk-&y-scientists and experts could be improved by the use of judgement analysis because it describes scientists' and experts' cognitive activity rather than their motives, externalizes parameters of their judgement process that otherwise remain obscure, and assists in the development of explicit rather than implicit, theories that are open to criticism and modifications based on the scientific literature.

5. CASE STUDIES

Case studies are a useful tool by which practical considerations for the incorporation of RA and EIA could be examined. These studies would also serve to give greater credibility for RA procedures.

Further study involving case studies could involve:

5.1 Much of the available information on risk is often arcane, conceptual and theoretical. There is a need to use actual case studies to evaluate the various approaches to RA methodologies as they apply to EIA. This research could be of great use in the future development of protocol5 for the use of RA in EIA.

5.2 A practical way to meet this objective would be to identify the current uses of RA in EIA. As shown by Paradine (1985) and Grima et al. (1985), risk has already been applied in a limited manner in EIA. It would be beneficial to identify when risk analysis was used, and if the use of RA made the EIA more comprehensive, releuant and of greater use to the environmental decisionmakers.

5.3 The utility of multicriteria evaluation methods in both RA and EIA should be studied using case studies (see section 6).

6. MITIGATION OF RISK

One of the primary objectives of EIA is to predict in a systematic manner the consequences of a proposed projects. Because planned projects and subsequent risks affect many different groups with differing interests and concerns, conflicts will arise. These conflicts can be difficult to resolve in a fair, equitable manner. As identified by Vlek et al. (1985), "some wise combination of expert professional judgement and explicit decision analysis seem5 most acceptable for dealing with complex decision problems.. .When sociotechnical systems are designed to serve, and potentially harm, ever larger segments of a countrys population, the development of pleuristicsocial decision schemes becomes all the more urgent".

The treatment of alternatives is a complex process and a detailed discussion of its role in EIA and RA is beyond the scope it this paper, The advantages and disaduantages of serveral multi-criteria eualuation methods which could be used to examine alternatives in an Elk are discussed in a paper by Maclaren (1986), although no specific research needs for their utilization were giuen.

General research needs in this area are:

6.1 The difference between analyzed and perceiued risk is at the core of many environmental disputes. Research is needed into practical means to resolve differences of preference5 that arise from differences in analyzed and perceived risk. This involves research of the negotiation type that Kunreuther at Wharton School and conflict analysis that Hipel, Fraser, and Kilgour at University of Waterloo have begun.

6.2 Risk is usually perceived differently by different people or groups of people. Hypergames (e.g. Fraser and Hipel, 1984) can be used to formally structure the differing perceptions among the actors in an environmental dispute. A suitable topic for further studies is to determine how differing perceptions of risk could be effectively studied using hypergames and conflict analysis.

6.3 To reach a settlement to reduce the risk involved in a given project, a negotiated settlement is often required. Research is needed to ascertain the link among conflict analysis, bargaining and negotiation, and risk,

6.4 To clearly demonstrate the utility and efficiency of employed conflict analysis in EIA and RA, a number of case studies should be analyzed.

7. TRAINING

7.1 For RA to be used successfully as a tool for environmental decisionmaking, research is required to determine how widely differing disciplines such as engineering, psychological and political sciences can be better integrated to work in a convergent , rather than parallel or even divergent fashion

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