Integrated Environmental Management Information Series

Impact Significance

5

Department of Environmental Affairs and Tourism

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PREFACE

This document is one of a series of overview information reports on the concepts of, and approaches to, integrated environmental management (IEM). IEM is a key instrument of South Africa's National Environmental Management Act (NEMA). South Africa's NEMA promotes the integrated environmental management of activities that may have a significant effect (positive and negative) on the environment. IEM provides the overarching framework for the integration of environmental assessment and management principles into environmental decision-making. It includes the use of several environmental assessment and management tools that are appropriate for the various levels of decision-making.

The aim of this document series is to provide general information on techniques, tools and processes for environmental assessment and management. The material in this document draws upon experience and knowledge from South African practitioners and authorities, and published literature on international best practice. This document is aimed at a broad readership, which includes government authorities (who are responsible for reviewing and commenting on environmental reports and interacting in environmental processes), environmental professionals (who undertake or are involved in environmental assessments as part of their professional practice), academics (who are interested and active in the environmental assessment field from a research, teaching and training perspective), non-governmental organizations (NGOs) and interested persons. It is hoped that this document will also be of interest to practitioners, government authorities and academics from around the world.

This document has been designed for use in South Africa and it cannot reflect all the specific requirements, practices and procedures of environmental assessment in other countries.

This series of documents is not meant to encompass every possible concept, consideration, issue or process in the range of environmental assessment and management tools. Proper use of this series of documents is as a generic reference, with the understanding that it will be revised and supplemented by detailed guideline documents.

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The opinions expressed and conclusions drawn are those of the author and are not necessarily the official view of the Department of Environmental Affairs and Tourism. Any misrepresentation of views or errors of fact are solely those of the author.

All sources used have been acknowledged by means of complete references.

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SUMMARY

Significance as a concept is at the core of impact identification, prediction, evaluation and decision-making in environmental impact assessment (EIA) processes. Deciding whether a project is likely to cause significant negative environmental effects is central to the practice, administration and decision-making in EIA. Despite this, the concept remains largely undefined. A variety of definitions and explanations of the concept of significance exists. Currently there is no international consensus among practitioners on an agreed approach for assessing the significance of impacts. This, however, is not necessarily a weakness. It is a strength that the concept of significance can be adapted to different political, social and cultural contexts.

The process of determining impact significance includes the following tasks: impact identification, impact prediction and impact evaluation. Any consideration of the significance of environmental effects must acknowledge that EIA is inherently an anthropocentric concept. It is centred on the effects of human activities and ultimately involves a value judgement of the significance of these effects. Such judgements reflect the reality of EIA practice. Ideally significance should be communicated from a variety of perspectives, for example from public, political, scientific and economic perspectives. EIA practitioners are sometimes required to extend their evaluation of impacts beyond their professional perspective and to emphasize those environmental attributes perceived by society to be significant.

Evaluating the significance of environmental impacts is linked to all the phases of the EIA process. It is used throughout the process and formal or intuitive evaluations can be made at different stages. An example is at the application or screening stages, where some countries have prescribed lists of projects for which EIA is compulsory.

The concept of significance has different meanings at different stages of the EIA process. For example, in screening, it is used to determine whether an environmental assessment is required or not. In the decision-making stage, significance is used to weigh and rank impacts (positive and negative) and make compromises or trade-offs.

Lessons from the published literature and South African EIA practice reveal that:

- if scoping is not done properly, the EIA team can exert strong influence on determining what key issues are to be addressed.
- multiple perspectives and opinions are often articulated during the EIA process. The EIA team often determines impact significance from a professional perspective. Public input and values seldom inform the determination of significance and acceptability of impacts.
- the value judgements contained within scientific information are not made explicit.

Judgement and values are used to a greater extent in EIA than science-based criteria and standards. Therefore impact prediction and assessment of significance should include a consideration of value judgements and whose values they represent.

This document focuses on the concept of significance in the identification, prediction and evaluation of impacts. The aim is to provide an overview of the key literature sources on the topic. Various definitions of the concept of significance are provided. An overview of formal methods to determine impact significance is given. Selected generic approaches to determine impact significance and thresholds of significance are described. This document does not prescribe or recommend specific methods, but rather provides an overview of the key criteria to consider in determining significance.

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1. Introduction

In the absence of consensus, both in South Africa and internationally, with respect to the determination of impact significance, this document provides a comprehensive review of the international literature to highlight that this is one aspect of EIA that has taxed experts globally.

Formal EIA methods and generic approaches were developed in order to (1) identify the potential impacts of a proposed development on the environment, (2) predict the likely nature of such impacts and (3) evaluate the significance of the potential impacts.

Impact Identification

A number of methods can be used to identify the major impacts of a proposed development. Methods for impact identification have been divided by Munn (1979) and Canter (1996) into the generic classification of matrices, networks and checklists. Shopley and Fuggle's (1984) classification include both methods and techniques. The categories for impact identification listed by Shopley and Fuggle (1984) include the following:

- Ad hoc approaches (e.g. project-, sector- or environment-specific guidelines).
- Checklists (i.e. the listing of potential impacts).
- Matrices (e.g. the Leopold Matrix).
- Networks (i.e. the presentation of higher order impacts and linkages using directional diagrams).
- Overlay maps (e.g. the McHarg technique).
- Modelling procedures (i.e. computerized, mathematical, physical scale models or descriptive models).

Impact Prediction

Once potential impacts have been identified, further investigation is required to predict the nature of the impact. Predictions are based on simplified conceptual models of how natural processes function. Models range in complexity from those that are very intuitive to those based on explicit assumptions about environmental processes (Munn, 1979). Criteria that can be used to describe the nature of an impact include:

- spatial extent;
- duration of the impact;
- intensity or severity of the impact;
- status of the impact (i.e. either positive (a benefit) or negative (a cost) or neutral);
- reversibility (i.e. reversible or permanent);
- degree of certainty; and
- mitigatory potential.

Examples of the techniques or tools used in impact prediction are listed below:

- *Mathematical Models*
  Describe cause and effect relationships in the form of flow charts or mathematical functions.
- *Mass Balance Models*
  Describe inputs and outputs from a defined system.
- *Statistical Models*
  The use of statistical techniques to interpret and compare data.
- *Physical Models*
  Physical models are scaled down realistic constructions of a project. They are used to simulate interaction between the project and physical environmental processes.
- *Field or Laboratory Models*
  These are conceptual models constructed in the laboratory or field. Observation and collection of data enables the prediction of impacts.

Impact Evaluation

Once the impacts have been predicted and described, the significance of the impacts should be assessed. Significance can be described in terms such as:

- legal requirements; and
- acceptability.

2. Purpose of this Document

This document has been written for a wide audience. Its objective is to serve as an initial reference text. The aim is to provide an introductory information source to government authorities, environmental practitioners, non-governmental organizations (NGOs), industry, project proponents, academics, students and other interested and affected parties (I&APs).

This document focuses on the concept of significance in the identification, prediction and evaluation of impacts. The aim is to provide an overview of the key literature sources on this topic. Definitions of the concept of significance are provided in section 3. Examples of formal methods, which attempt to achieve consistency and consensus in the determination of impact significance, are described in section 4. Generic approaches and judgemental criteria, which can be adapted to individual contexts, are outlined in section 5. This document does not prescribe or recommend specific methods, but rather provides an overview of the key criteria to consider in determining significance.

3. Definitions of the Concept of Significance

The concept of significance is at the core of impact identification, prediction, evaluation and decision-making. Deciding whether a project is likely to cause significant environmental effects is central to the practice of EIA. Whatever environmental effects are addressed and whatever methods are used, the focus of EIA always narrows down to a decision about whether the project is likely to cause significant *adverse* environmental effects (Canadian Environmental Assessment Agency, 1992). Despite this, the concept remains largely undefined and there is no international consensus on a single definition. Selected examples of definitions or interpretations from various authors are provided in Table 1. Even though a number of definitions or interpretations of the concept of significance exist, there is, however, some degree of commonality. Sippe (1999), recognized the following common elements from the various interpretations:

- Environmental significance is a value judgement.
- The degree of environmental significance depends on the nature of the impact.

- The importance is rated in terms of both biophysical and socio-economic values.
- Determining significance involves the amount of change to the environment perceived to be acceptable to affected communities.

Any process of identifying and evaluating impacts must recognize that the determination of impact significance is inherently an anthropocentric concept (Duinker and Beanlands, 1986, Sadler, 1996, Sippe, 1999). Specialists involved in EIA are often required to extend their interpretation of impacts beyond the limits of their professional subject and to emphasize those environmental attributes perceived by society to be important. Ultimately, impacts should be measured against the yardstick of human values. Any comprehensive definition of a significant impact with respect to EIA must reflect this value judgement (Duinker and Beanlands, 1986). Impact prediction and the assessment of significance should thus include a consideration of value judgements and whose values they represent.

Different stakeholders may have widely diverging views of what significance means. For example, sections of the community who are directly affected by a proposed project may regard any identifiable impact as significant (Hilden, 1996). On the other hand, if a project is proposed for siting in a sensitive environment (e.g. a national park), certain stakeholders who are far removed from project impacts (but interested in issues such as biodiversity) may also consider any identifiable impacts as significant.

Table 1: Selected examples of the definitions or interpretations of the concept of significance.

Source	Definition or interpretation
Haug *et al.* (1984)	Determining significance is ultimately a judgement call. Judgemental factors can be applied rigorously and consistently by displaying information related to an issue in a standard worksheet format. Issues are analyzed using a simple worksheet that identifies who is concerned, what specific elements of the environment they are concerned about, and why they are concerned. The significance of a particular issue is determined by a threshold of concern, a priority of that concern, and a probability that a potential environmental impact will, in fact, cross the threshold of concern.
Federal Environmental Assessment Review Office (1983), cited in Duinker and Beanlands (1986)	A significant impact is one where anticipated future conditions, environmental or social, resulting from the proposed action differ from those otherwise expected from normal change, and where this anticipation raises serious concerns among a professional or lay section of the Canadian public.
Duinker and Beanlands (1986)	Significance of environmental impacts is centred on the effects of human activities and involves a value judgement by society of the significance or importance of these effects. Such judgements, often based on social and economic criteria, reflect the political reality of impact assessment in which significance is translated into public acceptability and desirability. Any exercise in judging the significance of an environmental impact should thoroughly consider: (a) the importance of the environmental attribute in question to project decision-makers, (b) the distribution of change in time and space, (c) the magnitude of change, and (d) the reliability with which change has been predicted or measured.
Council on Environmental Quality (1987)	The United States' National Environmental Policy Act requires significance to be determined within the framework of context and intensity. *Context:* This means that the significance of an action must be analyzed in several contexts such as society as a whole, the affected region, the affected interests, and the locality. *Intensity:* This refers to the severity of impact. The following are among the considerations in evaluating intensity: (1) Impacts that may be both beneficial and adverse, (2) the degree to which the proposed action affects public health or safety, (3) unique characteristics of the geographic area, (4) whether the action is related to other actions with individually insignificant but cumulatively significant impacts, (5) the degree to which the action may adversely affect an endangered or threatened species or its habitat, and (6) whether the action violates legislative requirements.
Thompson (1988, 1990)	The significance of an impact is an expression of the cost or value of an impact to society. The focus of EIA must be a judgement as to whether or not impacts are significant, based upon the value judgements of society, or groups of people chosen to represent the wishes of society. If this is accepted, then it is clear that an assessment of the way in which significance is handled by formal methods should include consideration of the value judgements made, whose values they actually represent, and whether or not they can be taken as representative of society as a whole. Unless a method contains specific provision for an element of public opinion, there is a danger that the views of the EIA study team may exert undue influence upon the result. Few would question the use of experts to define and quantify impact prediction, but leaving them as sole arbiters of significance is open to challenge.
Canter and Canty (1993)	Significance can be considered on three levels: (1) significant and not mitigatible, (2) significant but mitigatible, and (3) insignificant. Significance is sometimes based on professional judgement, executive authority, the importance of the project/issue, sensitivity of the project/issue, and context, or by the controversy raised. Decisions of significance will not necessarily be determined on verifiable evidence, but may include intuition. Describing the impacts in terms of type, scale, complexity, intensity and duration develops a basis for comparison and the application of judgement.
US Environmental Protection Agency (1993)	Determination of significance requires predicting change. These impact predictions are along with societal values, the major input to significance determination. Ideally, change should be compared against thresholds of concern, some of which may be legally mandated and others which may be levels or states of valued components determined by the public, authorities or the EIA team.
Sadler (1996)	The evaluation of significance is subjective, contingent upon values, and dependent upon the environmental and community context. Scientific disciplinary and professional perspectives frame evaluations of significance. Scientists therefore evaluate significance differently from one another and from local communities.
Sippe (1999)	Environmental significance is an anthropocentric concept, which uses judgement and values to the same or greater extent than science-based criteria and standards. The degree of significance depends upon the nature (i.e. type, magnitude, intensity, etc.) of impacts and the importance communities place on them.

From a technical, conceptual or philosophical perspective, the focus of EIA ultimately narrows down to a judgement on whether the predicted impacts are significant. Significance is relative and must always be set in a context. Examples of factors to be considered in such a context include (a) competition for resources, (b) environmental sensitivity, (c) social sensitivity and (d) the scale and rate of development (Duinker and Beanlands, 1986).

4. Overview of Formal Methods

This section provides an overview of formal methods for identifying, predicting and evaluating impact significance. Most of the formal methods described in this section have been designed for application in specific contexts (e.g. water resource planning) or for specific project proposals (e.g. routing of roads).

The determination of impact significance from predictions of the nature of impacts is a source of debate in the field of environmental assessment. Of particular concern is the use of formal quantitative methods for comparing project alternatives in order to produce a total impact score for each alternative. It has been argued that these techniques remove the responsibility for the decision from the responsible authorities (Thompson, 1988, 1990). It is necessary to distinguish between impact magnitude and impact significance. Impact magnitude is determined by prediction based on empirical measurements, while impact significance is an expression of the cost of a predicted impact to society (Thompson, 1988, 1990). The approaches to handling impact significance, as outlined below, exhibit a wide variety of techniques. They vary from the rigidly quantitative to the qualitative.

According to Thompson (1988), significance can be determined in terms of a three-stage process involving scaling, weighting and aggregation.

Scaling is the standardization of empirical data onto a common scale to allow comparisons between different types of impacts. Determining the significance of impacts may be aided by finding a common basis for comparing the magnitude of predicted impacts. A number of scaling techniques can be employed to do this, e.g. nominal scaling, ordinal or discrete scaling, interval and ratio scaling.

Weighting is the imposition of professional and/or societal values on a range of potential environmental impacts. This is a very contentious area, revolving around a number of issues, such as: (1) Whose values should be considered?; (2) How representative are they?; and (3) How should such values be elicited?

Aggregation is the combination of different types of impact values to produce composite scores, which facilitates a comparison of project alternatives. Certain methods employ various means of summation to allow a final preference ranking to be achieved. Aggregation can also be achieved by composite maps or photographic overlays. Some methods use additive summarization of plus and minus scores, which implicitly weigh all inputs equally. Others produce aggregation in the form of computer-generated clusters of highly rated impacts.

The descriptions of the formal methods below have been sourced from Munn (1979), Shopley and Fuggle (1984) and Thompson (1988, 1990).

4.1 Methods in which aggregation is used to facilitate comparison of project alternatives

The methods in which aggregation is used to facilitate comparison of project alternatives include the Battelle Method (Dee et al., 1973), the Water Resources Assessment Method (Solomon et al., 1977), the Optimum Pathway Matrix Approach (Odum, 1971), the Tulsa Method (US Army Corps of Engineers, 1972), the Component Interaction Matrix (Ross, 1976) and the Krauskopf and Bunde Method (Krauskopf and Bunde, 1972). These methods handle impact significance distinct from impact magnitude. The methods utilize aggregation to facilitate the comparison of project alternatives. None of the methods has specific provision for inclusion of public opinion.

The Battelle Method (Dee et al., 1973)

This involves a weight-scaling checklist in which weighting of impacts is achieved by the use of socio-psychological scaling techniques.

The Battelle Method was designed to assess impacts of water resource developments, water quality management plans, highways and nuclear power plants. An example of the weights assigned to different resources is given in Table 2. The bracketed number that follows each entry in Table 2 is the relative weight assigned to each impact indicator. The weights are fixed for all similar types of projects (i.e. they do not vary from project to project, once they have been assigned). Given the value of each impact indicator and the associated weight, the overall impact of each project alternative may be calculated by adding the weights assigned to each indicator. The system also incorporates a warning system in which a series of red flags are used to indicate that:

- the value of an impact indicator cannot be estimated because of inadequate data; or
- the value of a particular impact indicator is unacceptable.

Red flags indicate areas where further studies are needed.

Table 2: The Battelle environmental classification for water resource development projects (the bracketed numbers are relative weights)

ECOLOGY	PHYSICAL/CHEMICAL
Terrestrial Species and Populations • Browsers and grazers (14) • Crops (14) • Natural vegetation (14) • Pest species (14) • Upland game birds (14) *Aquatic Species and Populations* • Commercial fisheries (14) • Natural vegetation (14) • Pest species (14) • Sport fish (14) • Water fowl (14) *Terrestrial Habitats and Communities* • Food web index (12)	*Water Quality* • Basin hydrologic loss (20) • Biochemical oxygen demand (25) • Dissolved oxygen (31) • Faecal coliforms (18) • Inorganic carbon (22) • Inorganic nitrogen (25) • Inorganic phosphate (28) • Pesticides (16) • pH (18) • Stream flow variation (28) • Temperature (28) • Total dissolved solids (25) • Toxic substances (14) • Turbidity (20)
AESTHETICS	**HUMAN INTEREST /SOCIAL**
Land • Geologic surface material (6) • Relief and topographic character (16) • Width and alignment (10) *Air* • Odour and visual (3) • Sounds (2) *Water* • Appearance of water (10) • Land and water interface (16) • Odour and floating material (6) • Water surface area (10) • Wooded and geologic shoreline (10)	*Education/Scientific* • Archaeological (13) • Ecological (13) • Geological (11) • Hydrological (11) *Historical* • Architecture and styles (11) • Events (11) • Persons (11) • Religions and cultures (11) • Western Frontier (11)

Source: Munn (1979)

It is argued that the assignment of weighting is necessary to reduce subjective input and allow for replicability. The weakness of this method is that significance cannot be predetermined before the magnitude of impacts is predicted. In addition, this method does not take into account that the magnitude of impacts and their significance is determined by the specific environmental and social context of the project.

The Water Resources Assessment Method (Solomon et al., 1977)
This method focuses on the development of appropriate scaling and weighting systems. Biophysical, social and economic components are weighted by an interdisciplinary team. The values obtained for the effects of each project alternative on specific components are expressed in terms of *Alternative Choice Coefficients*. Weighting and scaling values are multiplied in a matrix to produce a final score for each alternative. This method is similar in principle to the Battelle Method.

The Optimum Pathway Matrix Approach (Odum, 1971)
This is a linear combination of values (for individual environmental attributes) multiplied by a subjectively determined weighting factor to give the relative importance of a particular environmental component. Actual values are expressed as a decimal of the largest impact. The subjectively determined weighting factor is the sum of 1 X a weight for initial impacts and 10 X a weight for long-term effects. Analysis is conducted over a number of iterations and incorporates error variation in both actual measurements and weights. The limitation of this method is its low replicability because of the subjective weighting factors.

The Tulsa Method (US Army Corps of Engineers, 1972)
This method is a weighting scaling checklist or matrix. It measures magnitude by a negative impact system, using the *no-go* project alternative as a baseline. It then allocates scores from -5 to +5. Assignment of importance to the variables is done by professional judgement of an interdisciplinary team. The method does not have guidelines on how impacts should be measured.

The Component Interaction Matrix (Ross, 1976)
This technique is derived from component interaction matrix methods. A series of judgements are made by a panel on a paired comparison basis for each project alternative. These are combined and scaled, using a computer programme. It is estimated that each person on the panel is required to make over 2000-paired comparisons. The approach has been criticized for being very technical and for obscuring nearly all the information that goes into making the paired comparison choices.

The Krauskopf and Bunde Method (Krauskopf and Bunde, 1972)
This approach uses map overlays based on a grid system of one kilometre squares. Impact significance is estimated through the specification of subjective weights. Because it is computerized, the effect of several different weighting schemes can be readily analyzed. This allows a demonstration of which weighted characteristics are central to the choice of a particular alternative.

4.2 Methods in which there is limited consideration of impact significance

The methods in which there is limited consideration of impact significance include the Hill Goals Achievement Matrix (Hill, 1966), the Sondheim Method (Sondheim, 1978), the Crawford Method (Crawford, 1973) and the Stover Method (Stover, 1972). Public input forms part of the process in three of the four methods.

The Hill Goals Achievement Matrix (Hill (1966)
Desired goals for a project are considered and ranked in order of relative importance. Impacts are classified according to the community groups that are affected by them. Each alternative's level of achievement for each objective is estimated, weighted by the value of that objective, and recorded along one axis on which specific environmental goals are listed, while the other axis displays land use categories. By examining the matrix horizontally, a comparison is afforded between alternatives with respect to one specific location for all goals. A vertical examination gives a comparison in terms of one goal and all land use categories. This approach is very demanding and requires detailed impact information. It is perhaps biased towards assessing the degree to which goals are met, rather than assessing the environmental consequences of meeting them. Public involvement is not by direct input. The number of persons affected by an action is, however, considered in the weighting process.

The Sondheim Method (Sondheim, 1978)
A co-ordinating body appoints a group of experts to a rating panel, while representatives of government, industry, and local interest, community and pressure groups form a weighting panel. Each member of the weighting panel is responsible for evaluating each aspect of the project. The weightings are not determined by defined procedures, but are determined by the extent to which each of the aspects is significant to the individual or the organization or sector they represent. There is no requirement to arrive at a consensus. The outcome is largely determined by the composition of the weighting panel.

The Crawford Method (Crawford, 1973)
This method makes extensive use of public involvement. The approach was devised for use in highway route planning. Three reference groups are used to gain information on (1) the assignment of relative weights, (2) the prediction of consequences of alternatives to be evaluated, (3) estimates of probability for the predicted consequences and (4) numbers to represent the magnitude of the impact of each consequence on each evaluation criterion. A multi-disciplinary panel of experts is responsible for predicting consequences and estimating probabilities for each alternative. Estimates of impact magnitude are developed on a 7-point scale from +3 (strongly positive) to -3 (strongly negative). The impact of an alternative on each of a set of evaluation criteria is then calculated by multiplying impact size by its probability. The method is designed to produce a numerical measure of the extent to which each of the alternatives under evaluation impacts either positively or negatively on each evaluation criterion. This provides a basis for analyzing the value trade-offs that would be involved in a decision among these alternatives.

The Stover Method (Stover, 1972)

The essential feature of this method is the development of an *environmental impact index*, which is a product of the initial impact plus the future impact, multiplied by the estimated length of the project in years. An interdisciplinary team is responsible for assigning numerical values by using a rating system that considers the magnitude and significance of the proposed development, now and in the future. An *alternative proportional value* is then calculated to allow a comparison of impacts of alternative design concepts on each significant environmental function. For each environmental function, the alternative that will have the most significant impact on that function is assigned a value of 1. All other alternatives are then rated in proportion to their effect on the same function. The *functional impact value*, a product of multiplying the *environmental impact index* and the alternative proportional value is produced, and these are summed for each alternative design concept. A comparison of the total *functional impact value* of all alternatives is then possible. This technique is presented as only one step in a total evaluation scheme. The method makes no specific provision for the inclusion of public opinion.

4.3 Method adapted to planning

This group contains one method, namely the Project Appraisal for Development Control Method, (Clark *et al.*, 1983).

The Project Appraisal for Development Control (PADC) Method, (Clark et al., 1983)

This method is an adaptive and comprehensive approach to impact assessment, developed specifically for the United Kingdom. The PADC manual provides a checklist of activities for conducting an impact analysis that is compatible with the planning structure. Guidelines are provided for the communication of impact information. Assignment of significance involves a choice of the following: (1) beneficial/adverse, (2) short-term/long-term, (3) reversible/ irreversible, (4) direct/indirect and (5) local/ strategic. No indication is given as to how comparisons between alternatives might be facilitated. The use of summary sheets is suggested as an aid to the identification of important impacts. Ranking and weighting is mentioned, but with a warning that it shouldn't create an illusion of objectivity. There is no provision for direct public input.

4.4 Method with no guide on significance determination

This group contains one method, namely the Leopold Matrix (Leopold *et al.*, 1971). No guidelines are provided on how significance should be determined. There is also no input of public opinion.

The Leopold Matrix (Leopold et al., 1971)

The pioneering approach to impact assessment, the Leopold Matrix, was developed by Dr Luna Leopold and others of the United States Geological Survey. The matrix was designed for the assessment of impacts associated with almost any type of construction project. Its main strength is as a checklist that incorporates qualitative information on cause-and-effect relationships, but it is also useful for communicating results. The Leopold system is an open-cell matrix that contains 100 project actions along the horizontal axis and 88 environmental 'characteristics' and 'conditions' along the vertical axis. The Leopold Matrix summarizes and displays the interactions between a list of project actions and environmental characteristics (see Figure 1). If a project action is recognized to have an effect on an environmental characteristic, the appropriate matrix cell is scored for potential impact magnitude and significance. Matrix cells relating project activities to environmental parameters are bisected by a diagonal line. For each cell in the matrix, a ranking system (scaled from 1 to 10) is given. The top left half contains values for impact magnitude, while the bottom right contains values for importance (see Figure 1). No guidelines are given for the evaluation of significance. It is accepted that the evaluation of importance will be based on the value judgement of the evaluator. A rating scheme (1 – 10) is suggested as a means of discouraging purely subjective opinion. Practitioners are required to quantify their judgement of probable impacts, and the reasoning behind the assignment of values for magnitude and importance should be provided.

Figure 1: Illustration of the Leopold Matrix, in which impacts are scored in terms of magnitude and importance (i.e. significance)

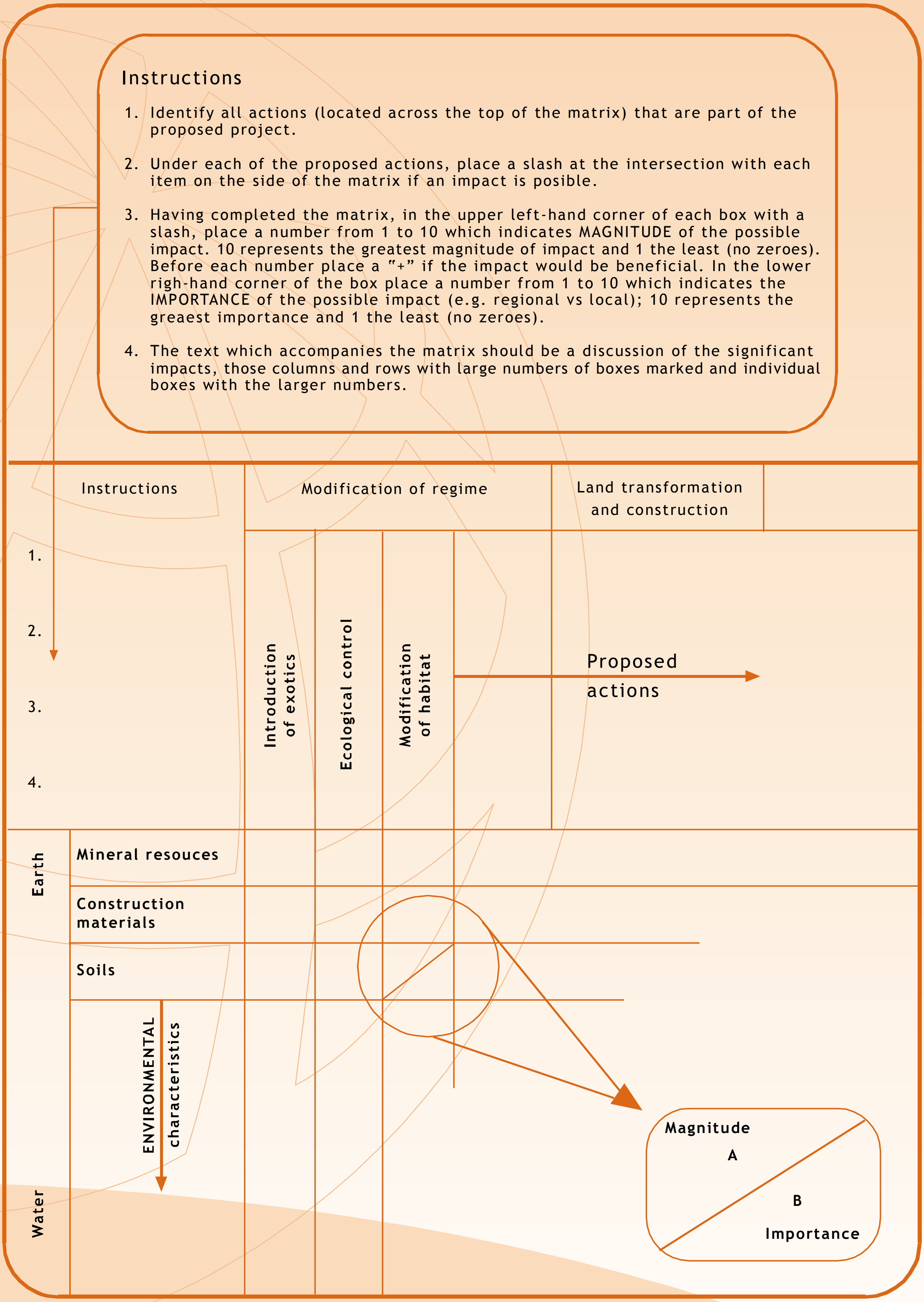


Diagram adapted from Munn (1979) and Shopley and Fuggle (1984).

The limitations of the Leopold Matrix are as follows:

- The matrix is not selective and does not focus on the key issues.
- The matrix does not distinguish between immediate and long-term impacts.
- The method does not provide a means for discriminating between quantitative and qualitative data.
- The matrix contains no provision for indicating scientific uncertainty.
- Explicit criteria for assigning numerical values of the weights, indicating relative importance of effects, are not given.
- A synthesis of the predictions is not possible, because the results are summarized in an 88 by 100 cell matrix. The decision-maker can therefore be presented with as many as 17 600 items for each project alternative.

4.5 Methods that use collective professional judgement

The methods in which significance are determined by the collective professional judgement of an interdisciplinary team include the Soil Conservation Service Guidelines (US Soil Conservation Service, 1977), the Fischer and Davis Method (Fischer and Davis, 1973), the Multi-Agency Task Force Method (US Bureau of Reclamation, 1972), the Environmental Impact Centre Method (US Department of the Interior, 1973) and the Walton and Lewis Method (Walton and Lewis, 1971).

The Soil Conservation Service Guidelines (US Soil Conservation Service, 1977)

No numerical weighting system is used. The scaling of impacts is achieved by the use of quantitative data plus a quality scale of 5 (excellent) to 1 (unsuited) for various resource uses. Interdisciplinary team meetings are held where open discussions on possible compromise and consensus take place. All decisions reached are recorded with reasons provided for each decision. The guidelines suggest that public input should determine whether impacts are labelled favourable or unfavourable, but give no indication as to how this would occur. This method makes use of network diagrams to communicate information. Figure 2 illustrates an example of a network diagram.

The Fischer and Davis Method (Fischer and Davis, 1973)

This involves a complex three-phase process, which is handled by an interdisciplinary team. The team uses its judgement to assign impacts as either "+" (benefit) or "_" (cost) and some guidance is given on how this should be done. Degrees of impact from low (1) to high (5) are subjectively assigned. Distinctions are made between short-term and long-term impacts. Judgement is based on a small number of significant impacts, while those of a lesser importance are ignored. Decisions are therefore focused on impacts judged to be high, while impacts of lower magnitude are undervalued.

The Multi-Agency Task Force Method (US Bureau of Reclamation, 1972)

This method involves a checklist approach according to which impacts are measured quantitatively whenever possible. Impacts are rated subjectively on a "quality" and "human influence" basis. In addition, "uniqueness" and "irreversibility" considerations are included where appropriate, at the discretion of the interdisciplinary team. Inadequate explanation is given as to how impacts are to be rated and interpreted. The approach does not label impacts as either benefits or costs, but only as impacts to be valued by others.

Environmental Impact Centre Method (US Department of the Interior, 1973)

This technique recommends the integration of existing methods, such as cost-benefit analysis, matrices and computer modelling, into a single unified method. Scaling involves impact predictions by the interdisciplinary team, but no system is suggested. There is no numerical weighting scheme, and importance weights are based on the collective professional judgement of the study team. Presentation is limited to quantitative impact predictions, with no method provided for aggregation. No alternative means for comparing project alternatives are suggested.

The Walton and Lewis Method (Walton and Lewis, 1971)

This method uses direct input from the public. It was developed for decisions on highway route alternatives. It is unique in its reliance on social impact categories, with noise, air and water pollution the only environmental impacts to receive consideration. Impacts are measured in dollar value or as a weighted function (determined by the study team) of the number of people likely to be affected. Public participation is the means for determining most impacts. Social groups likely to be affected are identified and interviews are carried out with a representative of each group. It is the first method to properly attempt to elicit views from people most likely to be affected by a proposed project.

4.6 Methods that involve no consideration of impact significance

These methods, which involve no consideration of impact significance, include the McHarg Technique (McHarg, 1971), the Loran Method (Loran, 1975), the Adkins and Burke Method (Adkins and Burke, 1974), the Environment Canada Method (Environment Canada, 1974), the KSIM Technique (Kane *et al.*, 1973), the Sorensen Method (Sorensen, 1971) and the Keeney and Robilliard Method (Keeney and Robilliard, 1977). These methods are characterized by a lack of consideration of impact significance, either intentionally or as a result of using procedures that mask the issue of significance.

The McHarg Technique (McHarg, 1971)

This technique was the forerunner to the current method of geographic information system (GIS) map overlays. It involves the overlay technique and was devised specifically for highway route selection. A series of transparencies is used to identify, predict, assign relative significance and communicate impacts. Transparencies are constructed for each impact type and overlaid to indicate areas of alignment and conflict. By a series of overlays, the land-use suitability, action compatibility, and engineering feasibility are evaluated visually in order to identify the best combination.

An implicit weighting exists within the technique in that the choice of comparative colour densities amounts to a judgement for weighting the relative importance of individual environment parameters. This method is useful for presenting land use data. Visual representation of impacts may carry considerable influence with decision-makers. The limitations of the method are as follows:

- The approach is selective, because there is a limit to the number of transparencies that can be viewed together.
- The overlay method is weak in estimating impact magnitude.
- Overlays are not effective in estimating or displaying uncertainty and interactions.
- Extreme impacts with small probabilities of occurrence are not considered.

Despite the limitations of the method, it is valuable in illustrating complex spatial pattern relationships. It is also useful for large regional developments and corridor projects.

The Loran Method (Loran, 1975)

This approach involves a matrix of 234 project activities and 27 environmental features. Each matrix element is scaled according to a forecast severity of impact from 0 (no impact) to 5 (severe impact), at the discretion of the interdisciplinary team. The matrix is recorded by using a computer algorithm and an aggregation of impacts is achieved via a "clustering of highly rated impacts". It is suggested that this serves to identify critical environmental areas, while grouping together similar activities and effects. No further evaluation is used and it is not made clear how project alternatives are evaluated.

The Adkins and Burke Method (Adkins and Burke, 1974)

This is another technique developed for the comparison of highway route alternatives. This technique is a scaling checklist, which scores impacts by subjective relative estimates from +5 to -5. No guidelines are given for the measurement of impacts. The number of negative scores is aggregated and average impact scores are used to compare project alternatives. Aggregation is possible via the summation of rating scores; alternatively the ratio of "+" and "_" scores can be used to supply an average rating. Aggregating by the addition of impact scores affords an equal weighting to each impact. This is problematic, because this method does not take into account the fact that each impact is not equally important.

The Environment Canada Method (Environment Canada, 1974)

This approach was developed specifically to compare port site alternatives. An interaction matrix is used to compare project characteristics on one axis against environment characteristics on the other. The alternatives are analyzed for the degree to which they would interfere with existing social and environmental interactions from 0 (no disruption) to 3 (severe disruption). This results in the ranking of alternatives. It is not, however, made clear how the matrices are used to derive the rank order of the project alternatives.

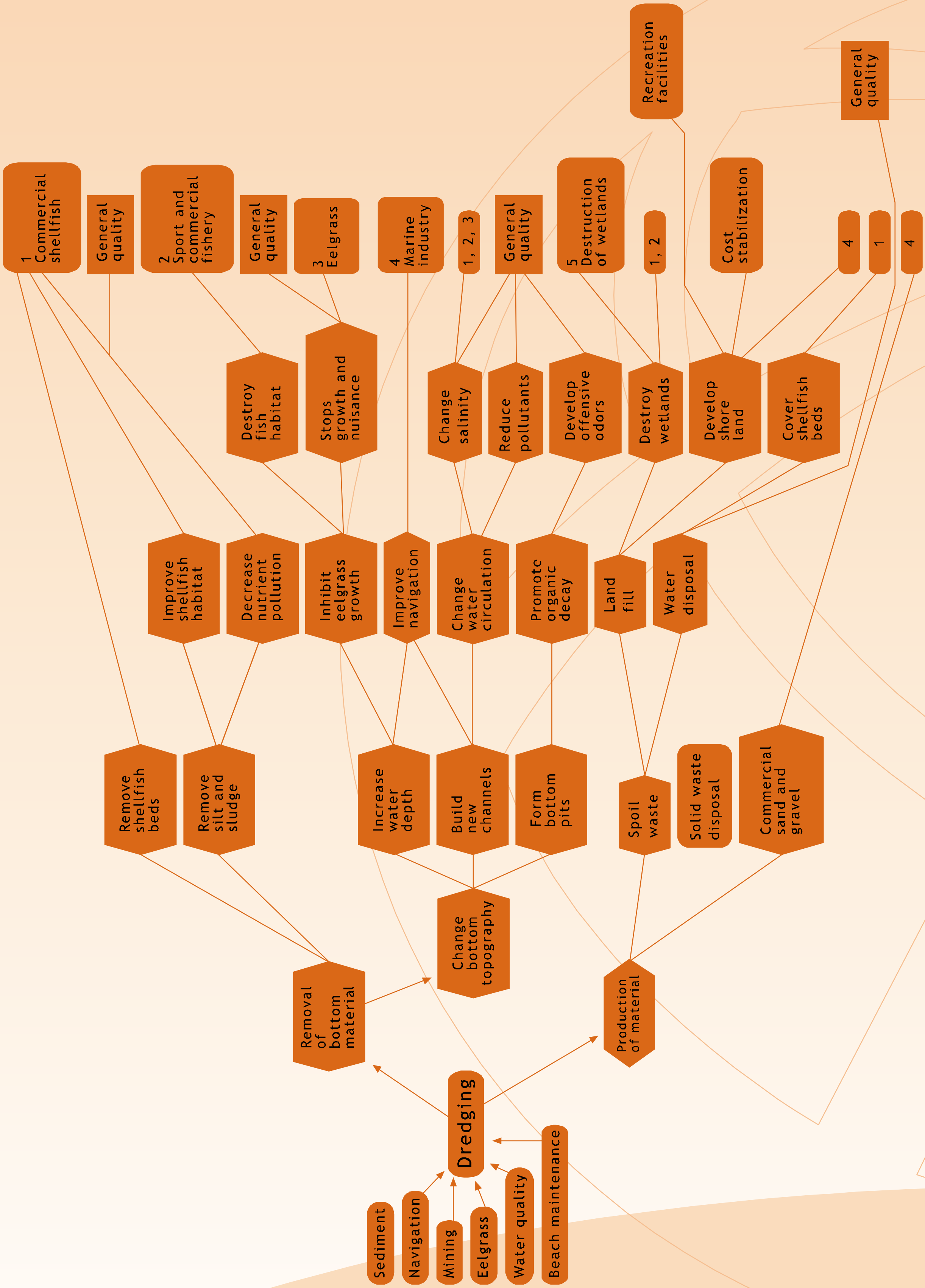
The KSIM Technique (Kane et al., 1973)

This method makes use of a mathematical model. A panel assesses inputs to the model which are awarded "+" or "-" (mild), or "++" or "__" (strong) or "+++" or "___" (overwhelming), for each impact. The values are converted to plus or minus 1, 2 or 3 for inclusion in the model. The reason for this conversion is that it is claimed to be easier for the panel to be objective with the use of plus or minus symbols than it would be with numerical values. In this case significance is thus handled implicitly by a panel in their prediction of values for each impact.

The Sorensen Method (Sorensen, 1971)

This method involves a network approach, which allows direct impacts to be followed through to higher order, indirect ones. Although principally concerned with presenting information, some degree of impact quantification can be introduced. More elaborate methods, using the probability of each branch of the network occurring as an estimate of its likely impact, can also be used. This method integrates impact causes and consequences. Network analyses are useful for (1) identifying anticipated impacts, (2) aiding in structuring the discussion of anticipated impacts and (3) communicating information to the public. Figure 2 illustrates a network diagram for a dredging project.

Figure 2:
Illustration of a network diagram for a dredging project (Source of diagram: Canter, 1996)



The Keeney and Robilliard Method (Keeney and Robilliard, 1977)
A precise method is outlined only for the ecological impact on salmonoid fish. It is claimed that their position at the top of the food chain, allied to a high sensitivity to environmental change, make them an ideal environmental indicator. The method is applied using the professional judgement and experience of biologists. Significance is not considered. The two inputs to the model are impact magnitude and probability.

4.7 Lessons learnt from the application of formal methods

The methods described above can be split into those that make use of public input and those that do not. Most of the methods use the professional judgement of an interdisciplinary study team to determine significance. It is acknowledged that expert opinion is central to determining impact magnitude. However, a major problem of using experts to determine significance results in expression of values from a professional perspective. The outcome of determining significance also depends on the group of professionals involved. The full range of views and values of the public cannot be known if only experts are used to determine impact significance. The challenge is to find a way to involve the public, so that a greater cross-section of views and values are elicited.

Wide variations are noticeable in the rigour, objectivity and level of quantification in the methods described above (Thompson, 1988, 1990). None of the methods provides a comprehensive approach for determining the significance of anticipated impacts. All of the techniques can be criticized from one or another perspective. For example, (1) they either summarize too much or not enough information, (2) they either attempt to quantify based on inadequate (subjective) data or remain too qualitative, (3) they may be arbitrary and incomplete in their selection of impacts and (4) they either remove too much judgement from decision-makers or leave too many unanswered questions (Westman, 1985). Thompson (1988, 1990) cautions against the standard application of the methods described above, because in each case the method is of secondary importance to the unique nature of the project and the associated environment. The contemporary alternative approach is to select methods to suit individual situations or to use international good practice guidelines (Sippe, 1999).

All the formal methods outlined above were developed in a period (i.e. the 1970s to 1980s) in which the quantification of impacts was at the heart of EIA. During this period the process of quantifying impacts and determining their significance was largely defined and determined by specialists. Public input into the process of determining significance varied from limited to none at all.

Cherp (1992) identified the following distinguishing features of the quantitative methods used to determine significance:

- Methods were specifically developed to determine significance differently from impact magnitude.
- The objective measurement of impacts was emphasized.
- The determination of significance was handled by experts using consistent, quantitative methods.
- The need to design objective and quantitative methods of determining significance was thought important, so that authorities could take objective decisions.
- Determining significance was discussed primarily in relation to the screening stage of the EIA process.

5. Overview of Generic Approaches and Criteria

This section provides an overview of generic approaches and criteria that can be adapted to specific contexts and project proposals. Examples of generic approaches (e.g. administrative criteria in section 5.1 and thresholds of significance in section 5.2) and judgemental criteria (in section 5.5) that can be used and adopted in different contexts and environmental settings are outlined.

Reaching consensus on the interpretation of significance is difficult, because of the varying backgrounds, opinions and values of stakeholders involved in the EIA process. According to Hilden (1996), part of the challenges concerning the evaluation of significance include:

- gathering information on whether a particular change will occur and how large that change is;
- determining the value of the change and whether the change may be positive for certain stakeholders and negative for others; and
- the different world views held by different stakeholders.

The challenges listed above mean that communicating scientific data as the central process in EIA will not resolve divergent views on the significance of impacts (Hilden, 1996). To solve some of the problems in evaluating significance, Hilden (1996) proposed two approaches:

1. Apply technical criteria when the likely changes associated with a proposal can be predicted with reasonable accuracy (either by modelling or other techniques). This approach can be based on environmental standards, objectives or specific quantified criteria.
2. Use general sustainability criteria when information is limited and there is scientific uncertainty. Qualitative interpretations can also establish a rational basis for decision-making.

Achieving a common understanding of significance in the EIA process can be facilitated by the use of generic approaches and judgemental criteria. The use of generic approaches and judgemental criteria is sufficiently broad enough for stakeholders holding opposing views to relate to and accept. The main challenge would be to ensure that the environmental impact reporting recognizes that different impacts have varying levels of significance for different stakeholders. Professional judgement should ideally be used in conjunction with the different value judgements expressed by various stakeholders. The choice of significance criteria needs to be aligned with a country's political culture and socio-economic framework. The three broad forms of recognition or determination of impact significance are summarized in Table 3.

Table 3: The three broad forms of recognition or determination of impact significance

Forms of recognition	Criteria
Institutional recognition	The importance of an environmental attribute or resource is acknowledged in the laws, plans or policy statements of government agencies or private groups.
Public recognition	Segments of the public recognize the importance of an environmental resource or attribute. Public recognition may take the form of support, conflict or opposition. Public action may be expressed formally (e.g. letters) or informally (e.g. protest action).
Technical recognition	The importance of an environmental resource or attribute is based on scientific or technical knowledge or judgement of critical resource characteristics.

Source: Canter (1996).

The forms of recognition of impact significance outlined in Table 3 are similar to the questions posed in the Canadian procedure to determine the significance of anticipated impacts (see Box 1 below). Box 1 lists a sequence of questions or levels that can be used to determine the significance of the resource and the anticipated impacts of a proposed project.

Box 1: Questions used in the Canadian procedure to determine the significance of an environmental resource and the anticipated impacts of a proposed project

1. Is the environmental component legally recognised as important?

- The environmental component is important if it is specifically protected by law, policy, plan, contol or regulation or is part of a legally defined management unit (e.g. national park).
- The level of legal protection (e.g. national, regional or local) and the type of protection (i.e. law, policy, plan, contol or regulation) can affect the level of importance.
- Present legal status, the past and future predicted status.
- Environmental components legally identified as significant are commonly, also publicly, politically and professionally identified as important and as such, usually rank high in relative importance.

2. Is the environmental component politically or publically recognised as important?

- Conditions affecting the recognition of an environmental component as politicaly and publicly important include:
  (1) conflict over the use(s);
  (2) resources availibility and supply, and changes to that base;
  (3) demand and changes in demand; and
  (4) knowledge about the component and changes in that knowledge.

- Importance can be identified by any segment of the public and the importance may be perceived, rather than real.
- Assessment of the importance of an environmental component based on public input should consider:
  (1) who and how many consider the environmental component to be important;
  (2) the history of the use;
  (3) the public's expectation of future use;
  (4) the value of the environmental component to the public (monetary and otherwise); and
  (5) real or perceived imporance

3. Is the environmental component professionally judged as important?

- Professional judgement may often form the only basis for recognising the significance of an environmental component. Careful documentation of that determination is essential.
- Key aspects evaluated by the professional in analysing the importance of an environmental component include:
  (1) past, present and projcted future condition in the assessment area;
  (2) the condition in the context of the local area, region, province, and the nation;
  (3) the size and extent of the environmental component;
  (4) scarcity;
  (5) monetary value; and
  (6)biological, physical and socio-economic attributes of the environmental component.

Source: Federal Environmental Assessment Review Office (undated), cited in Canter (1996).

Canter and Canty (1993) advocate that a sequenced approach be used to determine impact significance. A sequenced approach suggests several levels of consideration in determining the significance of the potential impacts of a policy, programme or plan. Significance of impacts can be determined by posing the sequence of questions listed in Box 2 below.

The presumption is that for those policies, programmes, plans or projects that may affect resources and are deemed to be significant, an environmental assessment would be required.

Box 2: Sequence of questions for determining significance of impacts

1. Do the proposed policy, programme, plan or project cause impacts that exceed the definition of significant as contained in pertinant laws, regulations or executive orders?
2. Is the quantitative threshold criterion exceeded in terms of the type, size or cost of the undertaking?
3. Is the action located in a protected habitat or land-use zone, or within an exclusionary zone relative to land usage? Is the environmental resource to be affected a significant resource?
4. Is the proposed undertaking expected to comply wih pertinant environmental laws, regulations, policies or executive orders?
5. What is the anticipated percentage change in pertinant environmental factors from the proposed action, and will the changes be within the normal variability of the factors? What is the sensitivity of the environment to the anticipated changes; or is the environment susceptible or resilient to changes? Will the carrying capacity of the resource (ability to support and maintain environmental processes) be exceeded?
6. Are there sensitive human, living or inanimate receptors to the environmental stressors from the proposed policy, programme, plan or project?
7. Can the anticipated negative impacts be mitigated in a cost-effective manner?
8. What is the professional judgement of experts in the pertinant substantive areas, such as water quality, ecology, planning, landscape, architecture and archaeology?
9. Are there public concerns due to the impact risks of the proposed policy, programme, plan or project?
10. Are there cumulative impacts that should be considered or impacts related to future phases of the proposed action?

Source: Canter and Canty (1993).

5.1 Examples of administrative criteria used to determine significance

5.1.1 Criteria used by the City of New York

The City of New York uses a process by which agencies review proposed projects and identify the effects those projects may have on the environment (City of New York, 2001). Based on an initial evaluation, an agency determines whether a project should be subjected to further environmental review. If the proposed project is subjected to environmental review, a series of technical areas, such as air quality, traffic and neighbourhood character, are considered in an initial assessment to determine whether the action may have a significant adverse impact on the environment. If the proposed project might have a significant adverse impact, the lead agency must consider (1) the potential of the project to generate significant adverse environmental impacts, (2) the alternatives that would avoid or minimize such impacts and (3) measures that would mitigate them (City of New York, 2001). The criteria used by the City of New York to determine significant impacts are given in Box 3.

Box 3: The criteria used by the City of New York for determining significant adverse impacts on the environment

- A substantial adverse change in existing air quality, ground or surface water quality or quantity, traffic or noise levels; a substantial increase in solid waste production; a substantial increase in potential for erosion, flooding, leaching, or drainage problems.
- The removal or destruction of large quantities of vegetation or fauna; substantial interference with the movement of any resident or migratory fish or wildlife species; impacts on a significant habitat area; substantial adverse effects on a threatened or endangered species of animal or plant, or the habitat of such a species, or other significant adverse effects to natural resources.
- The creation of a material conflict with a community's current plans or goals as officially approved or adopted.
- The impairment of the character or quality of important historical, archaeological, architectural, or aesthetic resources, or of existing community or neighbourhood character.

- A major change in the use of either the quantity or type of energy.
- The creation of a hazard to human health.
- A substantial change in the use, or intensity of use, of land, including agricultural, open space or recreational resources, or in its capacity to support existing uses.
- The encouraging or attracting of a large number of people to a place or places for more than a few days, compared with the number of people who would come to such a place without the action.
- The creation of a material demand for other actions which would result in one of the above consequences.
- Changes in two or more elements of the environment, none of which has a significant effect on the environment, but when considered together result in a substantial adverse impact on the environment.
- Two or more related actions undertaken, funded, or approved by an agency, none of which has or would have a significant effect on the environment, but when considered cumulatively would meet one or more of the listed criteria.

Source: City of New York (2001).

5.1.2 Criteria used by the State of California

The California Environmental Quality Act (CEQA) defines a significant effect as a substantial adverse change on the physical environment (Canter and Canty, 1993). Box 4 below contains a list of environmental effects that are considered as significant in California.

Box 4: The criteria used by the State of California for effects considered as significant

A project will normally have a significant environmental effect if it will:

- conflict with adopted environmental plans and community goals;
- have a substantial, demonstrable negative aesthetic effect;
- substantially interfere with the movement of resident or migratory fish or wildlife;
- breach published standards relating to solid waste or litter control;
- substantially degrade water quality;
- contaminate a public water supply;
- substantially degrade or deplete groundwater resources;
- substantially interfere with groundwater recharge;
- disrupt or adversely affect a cultural resource;
- induce substantial growth or concentration of population;
- cause a traffic increase that is substantial in relation to existing street traffic load and capacity;
- displace a large number of people;
- encourage activities requiring large amounts of fuel, water or energy;
- use fuel, water or energy wastefully;
- substantially increase ambient noise levels;
- cause substantial flooding, erosion or siltation;
- expose people or structures to major geologic hazards;
- extend a sewer trunk line with capacity to service new development;
- substantially diminish habitat for fish, wildlife or plants;
- create a potential public health hazard or expose people or animals and plants to hazards;
- conflict with established recreational, educational, religious or scientific uses;
- violate any ambient air quality standard, contribute substantially to an existing or projected air quality violation, or expose sensitive receptors to substantial pollutant concentrations;
- convert prime agricultural land to non-agricultural use or impair productivity or prime agricultural land; and
- interfere with emergency response plans or emergency evacuation.

Source: Bass and Herson (1991), cited in Canter and Canty (1993).

5.1.3 Criteria used by Environment Australia

An example of the list of criteria used by Environment Australia (2000) in the Environmental Protection and Biodiversity Conservation Act of 1999 for determining whether an action is likely to have a significant impact is given in Box 5 below.

Box 5: Selected criteria used by Environment Australia for determining whether an action is likely to have a significant impact

The matters of national environmental significance include:
- world heritage properties
- listed threatened species and communities
- migratory species protected under international agreements.

World heritage properties
Criteria
An action is likely to have a significant impact if it results in:
- one or more of the world heritage values being lost, or
- one or more of the world heritage values being degraded or damaged.

Listed threatened species and international communities
Extinct-in-the-wild species
Criteria
An action is likely to have a significant impact if it is likely to:
- adversely affect a captive or propagated population or one recently introduced/reintroduced to the wild, or
- interfere with the recovery of the species or its reintroduction into the wild.

Critically endangered species
Criteria
An action is likely to have a significant impact if it is likely to:
- lead to a long-term decrease in the size of a population,
- reduce the area of occupancy of the species,
- fragment an existing population into two or more populations,
- adversely affect habitat critical to the survival of a species, or
- disrupt the breeding cycle of a population.

Vulnerable species
Criteria
An action is likely to have a significant impact if it is likely to:
- lead to a long-term decrease in the size of an important population of a species,
- reduce the area of occupancy of an important population, or
- fragment an existing important population into two or more populations.

Critically endangered ecological communities
Criteria
An action is likely to have a significant impact if it is likely to:
- lead to a long-term adverse affect on an ecological community,
- reduce the extent of a community,
- fragment an occurrence of the community, or
- adversely affect habitat critical to the survival of an ecological community.

Listed migratory species
Criteria
An action is likely to have a significant impact if it is likely to:
- substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat of the migratory species,
- result in invasive species that is harmful to the migratory species becoming established in an area of important habitat of the migratory species, or
- seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population.

Source: Environment Australia (2000).

5.1.4 Criteria used by the Canadian Environmental Assessment Agency

The approach used by the Canadian Environmental Assessment Agency (1992) for deciding whether a project is likely to cause significant effects consists of three general steps:
- Step 1: Deciding whether the environmental effects are adverse.
- Step 2: Deciding whether the adverse environmental effects are significant.
- Step 3: Deciding whether the significant adverse environmental effects are likely.

Some of the major factors that are used by the Canadian Environmental Assessment Agency (1992) to determine whether environmental effects are adverse are listed in Table 4 below.

Table 4: Some of the factors used by the Canadian Environmental Assessment Agency to determine adverse environmental effects

Changes in the environment	Effects on people resulting from environmental changes
Negative effects on the health of biota, including plants, animals and fish.	Negative effects on human health, well- being or quality of life.
Threat to rare or endangered species.	Increase in unemployment or shrinkage in the economy.
Reduction in species diversity or disruption of food webs.	Reduction of the quality or quantity of recreational opportunities or amenities.
Loss of, or damage to habitats, including habitat fragmentation.	Detrimental change in the current use of lands and resources for traditional purposes by aboriginal persons.
Discharges or release of persistent and/or toxic chemicals, microbiological agents, nutrients (e.g nitrogen, phosphorous), radiation or thermal energy (e.g. cooling waste water).	Negative effects on historical, archaeological, palaeontological or architectural resources.
Loss of, or damage to commercial species.	Foreclosure of future resource use or production.

Source: Canadian Environmental Assessment Agency (1992).

According to the Canadian Environmental Assessment Agency (1992), the concept of significance cannot be separated from the concepts of adverse and likely. The central question for authorities is whether a project is likely to cause any significant adverse environmental effects. Only environmental effects that are both likely and adverse can be considered in determinations of significance. The approach used by the Canadian Environmental Assessment Agency (1992) is outlined in Table 5 below.

Table 5: Approach used by the Canadian Environmental Assessment Agency to determine whether environmental effects are adverse, significant and likely

Step	Criteria
Step 1: Deciding whether the environmental effects are adverse.	The quality of the existing environment is compared with the predicted quality of the environment once the project is in place. Some of the criteria listed in Table 4 above are used as variables
Step 2: Deciding whether the adverse environmental effects are significant.	Criteria used are: 1) magnitude 2) geographic extent 3) duration and frequency 4) degree to which the adverse environmental effects are reversible or irreversible 5) ecological context.
Step 3: Deciding whether the significant adverse environmental effects are likely.	Criteria used are: 1) probability of occurrence 2) scientific uncertainty.

Source: Canadian Environmental Assessment Agency (1992).

5.2 Thresholds of Significance

The determination of significant impacts relates to the degree of change in the environmental resource, measured against some standard or threshold. This requires a definition of the magnitude, prevalence, duration, frequency and likelihood of potential change. One example of a structured method for significance determination involves establishing a threshold of significance or concern (Canter, 1996).

A threshold represents that point at which a project's potential environmental effects are considered significant. It is an analytical tool for judging significance. A threshold can be defined as a quantitative or qualitative standard or a set of criteria against which the significance of a given environmental effect may be determined (California Environmental Quality Act (CEQA) Technical Advice Series, 1994). According to the CEQA Technical Advice Series (1994), a threshold may be based on aspects relating to:

- health-based standards, such as air pollutant emission standards, water pollutant discharge standards or noise levels;
- service capacity standards, such as transportation service, water supply capacity or waste treatment plant capacity; and
- ecological tolerance standards, such as physical carrying capacity and impacts on threatened or endangered species.

Thresholds can help to determine the significance of environmental effects, but are not necessarily conclusive. According to Haug *et al.* (1984) the advantages of thresholds are as follows:

- They are a means of making policy and legislation more rational, predictable and scientific.
- A project's potential significant environmental effects may be readily identified.
- Authorities are able to make consistent determinations of significance.
- Every project can be subject to a known set of evaluation criteria.
- EIA reviews undertaken by different individuals within an authority can use a standard method.
- The efficiency of reviewing and decision-making may be improved when the anticipated effects of a project are examined with reference to standard thresholds.
- Standardizing review criteria reduces duplication of effort and offer assurance that a comprehensive review has been made.
- They aid in screening and scoping a proposed project.
- Project proponents may be encouraged to incorporate mitigation into the design of the project prior to submitting an application.
- They focus analysis on tangible measurements of environmental consequences.
- They help to establish monitoring needs or criteria for mitigating impacts.

Thresholds may be qualitative or quantitative. Some effects, such as changes in traffic volumes or noise levels, lend themselves to numerical standards. Others, such as impacts on aesthetics or wildlife habitats, are difficult to quantify and must rely on qualitative descriptions. In either case, thresholds should be based on legal requirements or scientific standards, which indicate a point at which a given environmental effect becomes significant (CEQA Technical Advice Series, 1994). When policies, plans or standards do not actually limit the potential impacts of a project to a particular level, they are not effective measures of significance. Previous studies, research, surveys or monitoring data are additional sources of information for determining thresholds if they offer clear standards for assessing significance. These might include wetland boundaries, archaeological surveys or historical data records. The application of thresholds should be flexible. It should allow case-by-case deviation from the threshold when certain circumstances warrant it (CEQA Technical Advice Series, 1994).

Standardized mitigation measures can be provided in conjunction with adopted thresholds. The mitigation measures should be flexible enough to be tailored to individual projects. Standardized measures offer project proponents the opportunity to design their projects, so that environmental effects are minimized from an early stage. Standardized measures can also assure authorities and the public that potential effects will be mitigated on a consistent basis. Thresholds need not be established for every conceivable environmental effect. In fact, this is neither practical, nor desirable. Once adopted, thresholds should be reviewed periodically and revised when necessary to incorporate changes as the policy, socio-economic and biophysical environment change (CEQA Technical Advice Series, 1994). Examples of thresholds of significance for noise levels and exposure are given in Appendix A.

Adopting thresholds of significance should be related to levels of acceptability of environmental impacts. An example of levels of acceptability that can be applied in conjunction with threshold criteria are provided in Table 6.

Table 6: Examples of threshold criteria to determine the acceptability of environmental impacts

Level of acceptability	Threshold criteria for potential impacts
Unacceptable	Exceeds legal or regulatory standard, e.g. water quality standard. Increases level of risk to public health. Extinction of biological species, loss of genetic diversity, rare or endangered species, critical habitat.
Normally unacceptable	Conflict with policies or land-use plans. Loss of populations of commercial biological species. Large scale loss of productive capacity of renewable resources.
May be acceptable with mitigation	Avoidance of spread of biological disease, pests, feral animals or weeds. Some loss of threatened habitat.
Normally acceptable	Some loss of populations and habitats of non-threatened species. Modification of landscape without downgrading special aesthetic values. Emissions demonstrably less than the carrying capacity of the receiving environment.

Modified from Sippe (1999).

The use of predetermined criteria creates a defined threshold, thus allowing for a systematic determination of significance. This reduces the speculation involved in decision-making. However, the limitations of this form of determination are related to the rigidness of quantitative thresholds. In certain cases, there may be projects with significant impacts, but because they are below the established threshold level, they may be exempt from EIA (Canter and Canty, 1993).

The significance of an activity may vary in different environmental settings. More than one threshold of significance could be adopted for a given effect or flexible standards, which recognize differences in setting, could be included (CEQA Technical Advice Series, 1994). Developing a large number of threshold criteria is impractical, because it could lead to the development of extensive checklists. There are no guarantees that the checklists will improve the EIA process and enhance project proposals. A flexible, interactive process is more desirable than a rigid technical approach. It allows for flexibility and adjustment to local conditions and contexts (Hilden, 1996).

5.3 Quantitative Risk Assessment

Quantitative risk assessment is another method of determining significance. An example is health risk assessment, which is often used to determine the significance of the risks to human health from ionizing radiation and carcinogenic chemicals (Canadian Environmental Assessment Agency, 1992). The use of health risk assessment is restricted to agents that have predictable dose-exposure-response (effect/ risk) relationships. The response, effect, or risk is often measured in terms of increased cancer incidence per million people exposed. In quantitative risk assessment an "acceptable" level of risk is determined. By using the dose-response relationship, it can be determined if the exposure would result in an unacceptable level of risk. In other words, significance is determined based on an "acceptable level" of a specified risk, often cancer incidence. This approach assumes that there is an "acceptable" level of risk. In practice, occupational health and safety standards allow for a greater degree of risk than public exposure standards. The Delaney Clause in the US Food and Drugs Act establishes zero as the acceptable or significant increased cancer risk associated with food additives. It is important to be clear on who determines acceptable risk levels, as well as how they are determined, when quantitative risk assessments are included in EIAs. Quantitative risk assessment cannot only be used to determine significance, but also to determine the probability of significant environmental effects occurring, i.e. likelihood (Canadian Environmental Assessment Agency, 1992).

5.4 Framework for relating issues to significant impacts

Haug *et al.* (1984) developed a method for relating issues to significant impacts. It should be stressed that even though the context for the establishment of this method was the United States' National Environmental Policy Act (NEPA), it can be adapted to different contexts. NEPA requires a detailed statement (i.e. environmental impact statement) on the environmental consequences of actions that significantly affect the quality of the human environment. Haug *et al.* (1984) argue that a fundamental problem facing those trying to comply with NEPA centres around the word *significantly*. NEPA provides no clear definition of *significance* that can be applied objectively and uniformly to environmental issues. An issue is defined by Haug *et al.* (1984) as an unresolved question or concern about an environmental consequence. To relate issues to potential impacts, probing questions should be asked to those raising the issue to determine the underlying concerns. These questions should help differentiate between the *fact* and *meaning* of environmental consequences. The fact of an environmental impact is the measurable change (i.e. the magnitude, direction and estimated probability). The *meaning* of an environmental impact is the value placed on the change by different affected parties. The *meaning* is essentially the answer to the *so what question*. The *so what question* determines how important or significant an issue is, and to whom (Haug *et al.*, 1984).

The framework for determining significance, developed by Haug *et al.* (1984), is designed to elicit information about the underlying concerns. Identifying the types of impacts that people are concerned about is essential, but it is only part of the challenge. Additional information required is the *threshold of concern*.This is a value for an environmental impact, resource use or activity, which, if exceeded, causes impact or use to take on new importance. The value placed on an impact involves the *threshold of concern* and that threshold is related to the measurable change of the impact (Haug *et al.*, 1984).

The framework for relating issues to significant impacts involves (1) analyzing the significance of issues (Table 7), (2) ascribing priorities to impacts (Table 8), (3) estimating the probability of occurrence (Table 9) and (4) screening for thresholds of concern (Table 10).

Table 7: Method for analyzing the significance of issues

Criteria	Instruction
Issue	Write the issue in the form of a question or concern.
Date	Write the date on which each issue is articulated by the affected parties.
Affected party	Specify who will be affected by the environmental consequences.
Indicator	Specify the indicator of concern for which a threshold is established.
Baseline	Wherever possible, write a quantitative baseline value for the indicator.
Units of measurement	Specify the units used to describe or measure the indicator.
Environmental concern	Describe the potential environmental consequences about which people are concerned. It includes the threshold of concern, the priority of that concern, the probability of that threshold being exceeded and reasons why the threshold should not be exceeded.
Threshold	Write the quantity, which, if exceeded, would cause concern to the affected parties.
Priority	Assign a priority to the threshold (see Table 8 below).
Probability	Estimate a probability of exceeding the threshold. Specify any assumptions underlying the estimate or explain how the probability was derived at.
Context	Explain the factors that influence the relative importance of exceeding a threshold, i.e. why exceeding a threshold might be significant. Explain any factors that influence the relative importance of the consequences.

Source: Haug et al. (1984).

In Table 8 the criteria for ascribing priorities to thresholds are described using the method presented in Table 7 above. An issue is significant if there is a high probability that one or more impacts connected with that issue would exceed a threshold in one of the top three priorities.

Table 8: Criteria for ascribing priorities to impacts

Level of priority	Criteria
(1) Highest Priority	Legal thresholds. Thresholds of impacts or resource use established by law or regulation.
(2) Very High Priority	Functional thresholds. Thresholds established for resource use, or thresholds involving unavoidable adverse impacts on the human environment. If these thresholds are exceeded, the impacts will disrupt the functioning of an ecosystem sufficiently to destroy resources important to the nation or biosphere irreversibly and/or irretrievably.
(3) High Priority	Normative thresholds. Thresholds of impacts or resource use that are clearly established by social norms, usually at the local or regional level and often tied to social or economic concerns.

(4) Moderate Priority	Controversial thresholds. Thresholds of impacts or resource use that are highly controversial, or which are sources of conflict between various individuals, groups or organizations, and which do not warrant higher priority for other reasons.
(5) Low Priority	Preference thresholds. Thresholds of impacts or resource use that are preferences for individuals, groups or organizations only, as distinct from society at large, and which do not warrant higher priority for other reasons.

Source: Haug et al. (1984).

Determining the significance of one or more impacts is ultimately a judgement call. However, the method proposed by Haug *et al.* (1984) attempts to make the process more systematic by displaying information related to specific issues in a standard and transparent format. In this way, judgemental factors can be applied more rigorously and consistently. Table 9 below illustrates how thresholds can be linked to levels of probabilities or the likelihood of an impact occurring.

Table 9: Categories for probability (likelihood) of occurrence

Category	Definition
(A) High likelihood	Greater than 50:50 chance of occurrence *(P>0.5)*.
(B) Low likelihood	Less than or equal to a 50:50 chance, but at least a 1:20 chance of occurrence *(P£0.5, but >1:20)*.
(C) Negligible	Less than 1:20 chance of occurrence *(P<0.05)*.

Source: Haug et al. (1984).

Establishing ranges in the manner indicated in Table 9 above allows the user to set up probability categories (A, B or C), which can then be linked to priority levels (as set in Table 8). If an impact falls in categories 1A through 3A, it is significant (see Table 10). If it falls between 5A and 1C (see Table 10), it needs to be analyzed. Below 1C, impacts are considered negligible and may be omitted from further analysis. Category 4A can be left to the manager's discretion (see Table 10).

Table 10: Priority-probability screen for thresholds of concern

Priority	Probability category		
	A	B	C
1	Yes	No	No
2	Yes	No	Omit
3	Yes	No	Omit
4	Discretionary decision	No	Omit
5	No	No	Omit

Source: Haug et al. (1984).

5.5 Determining impact significance using systematic generic and judgemental criteria

Impact magnitude and significance should as far as possible be determined by reference to either legal requirements, accepted scientific standards or social acceptability. If no legislation or scientific standards are available, the EIA practitioner can evaluate impact magnitude based on clearly described criteria. Except for the exceeding of standards set by law or scientific knowledge, the description of significance is largely judgemental, subjective and variable. However, generic criteria can be used systematically to identify, predict, evaluate and determine the significance of impacts resulting from project construction, operation and decommissioning. The suite of potential environmental impacts (to both the natural and human environments) identified in the EIA should as far as possible be quantified. The process of determining impact magnitude and significance should never become mechanistic. Impact magnitude is determined by empirical prediction, while impact significance should ideally involve a process of determining the acceptability of a predicted impact to society. Making the process of determining the significance of impacts more explicit, open to comment and public input would be an improvement of EIA practice. The following generic criteria, which have been drawn from the published literature and South African practice, can be used to describe magnitude and significance of impacts in a systematic manner. The criteria are:

- extent or spatial scale of the impact;
- intensity or severity of the impact;
- duration of the impact;
- mitigatory potential;
- acceptability;
- degree of certainty;
- status of the impact; and
- legal requirements.

Describing the impacts in terms of the above criteria provides a consistent and systematic basis for the comparison and application of judgements. Ratings should be assigned for each criterion. The significance of impacts of the proposed project should be assessed both with and without mitigation action. The descriptors for the ratings are given in Table 11 below.

Table 11: Categories for the rating of impact magnitude and significance

Impact Magnitude and Significance Rating		
	High:	Of the highest order possible within the bounds of impacts that could occur. In the case of adverse impacts, there is no possible mitigation that could offset the impact, or mitigation is difficult, expensive, time-consuming or some combination of these. Social, cultural and economic activities of communities are disrupted to such an extent that these come to a halt. In the case of beneficial impacts, the impact is of a substantial order within the bounds of impacts that could occur.
	Medium:	Impact is real, but not substantial in relation to other impacts that might take effect within the bounds of those that could occur. In the case of adverse impacts, mitigation is both feasible and fairly easily possible. Social, cultural and economic activities of communities are changed, but can be continued (albeit in a different form). Modification of the project design or alternative action may be required. In the case of beneficial impacts, other means of achieving this benefit are about equal in time, cost and effort.
	Low:	Impact is of a low order and therefore likely to have little real effect. In the case of adverse impacts, mitigation is either easily achieved or little will be required, or both. Social, cultural and economic activities of communities can continue unchanged. In the case of beneficial impacts, alternative means of achieving this benefit are likely to be easier, cheaper, more effective and less time-consuming.
	No impact:	Zero impact.

Specific examples are given below of the type of impact criteria that can be used and adapted for a variety of contexts and projects.

Extent or spatial scale of the impact

A description should be provided as to whether impacts are either limited in extent or affect a wide area or group of people. For example, impacts can either be site-specific, local, regional, national or international.

Table 12: Examples of criteria for rating the extent or spatial scale of impacts

Rating	
High	Widespread. Far beyond site boundary. Regional/national/international scale.
Medium	Beyond site boundary. Local area.
Low	Within site boundary.

Intensity or severity of the impact

A description should be provided as to whether the intensity of the impact is high, medium, low or has no impact in terms of its potential for causing negative or positive effects. The study should attempt to quantify the magnitude of the impacts and outline the rationale used. When country-specific legal or scientific standards are not available, international standards can be used as a measure of the intensity of the impact.

Table 13: Examples of criteria for rating the intensity or severity of impacts

Rating	
High	Disturbance of pristine areas that have important conservation value. Destruction of rare or endangered species.
Medium	Disturbance of areas that have potential conservation value or are of use as resources. Complete change in species occurrence or variety.
Low	Disturbance of degraded areas, which have little conservation value. Minor change in species occurrence or variety.

Duration of the impact

It should be determined whether the duration of the impact will be short term (0 to 5 years), medium term (5 to 15 years), long term (more than 15 years, with the impact ceasing after the operational life of the development) or considered permanent.

Table 14: Examples of criteria for rating the duration of impacts

Rating	
High (Long term):	Permanent. Beyond decommissioning. Long term (More than 15 years).
Medium (Medium term):	Reversible over time. Lifespan of the project. Medium term (5 – 15 years).
Low (Short term):	Quickly reversible. Less than the project lifespan. Short term (0 – 5 years).

Mitigatory potential

The potential to mitigate the negative impacts and enhance the positive impacts should be determined. For each identified impact, mitigation objectives that would result in a measurable reduction in impact should be provided. If limited information or expertise exists, estimates based on experience should be made. For each impact, practical mitigation measures that can affect the significance rating should be recommended. Management actions that could enhance the condition of the environment (i.e. potential positive impacts of the proposed project) should be identified. Where no mitigation is considered feasible, this must be stated and the reasons provided. The rating both with and without mitigation or enhancement actions should be recorded. Quantifiable standards (performance criteria) for reviewing or tracking the effectiveness of the proposed mitigation action should be provided where appropriate.

Table 15: Examples of criteria for rating the mitigatory potential of impacts

Rating	
High:	High potential to mitigate negative impacts to the level of insignificant effects.
Medium:	Potential to mitigate negative impacts. However, the implementation of mitigation measures may still not prevent some negative effects.
Low:	Little or no mechanism to mitigate negative impacts.

Acceptability

Criteria and standards that exist for acceptability are either emissions-based or they relate to the receiving environment (e.g. air quality, water quality or noise). Establishing the acceptability of a potential impact is as important as determining its significance. An impact identified as being non-significant by a specialist may be unacceptable to a particular section of the community. On the other hand, a significant impact may be acceptable if, for example, adequate compensation is given. The level of acceptability often depends on the stakeholders, particularly those directly affected by the proposed project. Ratings that can be used for acceptability are given below.

Table 16: Examples of criteria for rating the acceptability of impacts

Rating	
High (Unacceptable):	Abandon project in part or in its entirety. Redesign project to remove or avoid impact.
Medium (Manageable):	With regulatory controls. With project proponent's commitments.
Low (Acceptable):	No risk to public health.

Degree of certainty

A description should be provided of the degree of certainty of the impact actually occurring as unsure, possible, probable, or definite (impact will occur regardless of prevention measures). Where relevant, there should be some cross-reference to key indices derived from a risk analysis study.

Table 17: Examples of criteria for rating the degree of certainty of impacts

Rating	
Definite:	More than 90% sure of a particular fact. Substantial supportive data exist to verify the assessment.
Probable:	Over 70% sure of a particular fact or of the likelihood of that impact occurring.
Possible:	Only over 40% sure of a particular fact or of the likelihood of an impact occurring.
Unsure:	Less than 40% sure of a particular fact or the likelihood of an impact occurring.

The following additional categories can also be used:

Status of the impact
Specialists should describe whether the impact is positive (a benefit), negative (a cost) or neutral.

Legal requirements
Specialists should identify and list the specific legal and permit requirements, which could potentially be relevant to the proposed project.

6. The Use of Significance at Different Stages of the EIA Process

Evaluating the significance of environmental impacts is a critical component of impact analysis. It is linked and used throughout the EIA process and formal or intuitive evaluations can be made at different stages. An example is in the screening stage, where some countries have prescribed lists of projects, activities or threshold criteria for which an EIA is compulsory. These project lists, activities or threshold criteria are in effect definitions of environmental significance. It is a mistake to think of significance evaluation as being limited to the analysis and impact reporting stage of an EIA. The stages in the EIA process where the concept of significance is used are indicated in Table 18.

The concept of significance has different meanings at different stages of the EIA process (see Table 18). For example, in screening it is used to determine whether an EIA is required or not. In the decision-making stage, significance is used to weigh and rank impacts (positive and negative) and make compromises or trade-offs.

Table 18: Stages in the EIA process where the concept of environmental significance is used

Stage in the EIA process	Objectives	Approaches and methods
Screening	Process that determines whether a project should be subject to an EIA because of its associated potential significant impacts.	Approaches used at this stage include (1) checklists of projects, activities or impacts and/or (2) predefined criteria such as thresholds of significance.
Scoping	Process in which key (significant) issues are raised and the focus is on determining the specific issues or significant impacts that need to be addressed in the EIA.	Approaches used at this stage include (1) facilitation (2) stakeholder engagement (3) negotiation and (4) mediation.
Specialist studies	This stage involves the identification and prediction of project impacts by specialists and the evaluation of their significance.	Approaches used at this stage include (1) numerical calculations or modelling, (2) experiments or tests, (3) physical or visual simulations, (4) mapping and (5) professional judgement.
Environmental impact report	This stage involves the preparation of a report by the EIA practitioner. The EIA practitioner integrates different forms of information and uses impact description and significance criteria to present the results to the decision-maker.	Approaches used at this stage include (1) predefined criteria for evaluating impacts, (2) professional judgement, (3) verbal description, (4) visualization; (5) mapping and (6) matrices.
Decision-making	The decision-maker uses judgement to rate and determine the significance and acceptability of impacts.	Approaches used at this stage include (1) professional judgement and (2) predefined criteria for evaluating, rating and weighting significant impacts.

7. Conclusions

The key challenges of determining significance are:

- scientific uncertainty (i.e. lack of, or limited information or understanding);
- communication of scientific information (it is difficult to communicate scientific information to the public, so that it is widely understood); and
- the multiplicity of values. (The parties involved in EIA view impact significance and its acceptability differently. Different groups of the public may have opposing views and even within a single group, values may vary).

Making the process of determining the significance of impacts more explicit, open to comment and public input would be an improvement of EIA practice. The current general practice of determining significance is to derive it from a combination of scientific methods and values ascribed by the EIA team. The various stakeholders involved in the EIA process are very seldom afforded an opportunity to relate their concerns, views and values to determining the significance of impacts. Including stakeholders in the process of determining the significance of impacts therefore represents a serious challenge to the current EIA practice. The evaluation of significance will remain contentious, even when using a structured generic approach or when using scientific criteria for thresholds of significance. For this reason impact prediction and assessment of significance should include a consideration of value judgements and whose values they represent.

Lessons from the published literature and South African EIA practice reveal that:

- if scoping is not done properly, the EIA team can exert strong influence on determining which key issues are to be addressed;
- the EIA team often determines impact significance from a professional perspective. Public input and values seldom informs determination of significance and acceptability of impacts;
- the value judgements contained within scientific information are not made explicit; and
- multiple perspectives and opinions are often articulated during the EIA process. There is seldom a community with a single viewpoint or value judgement. These varying values and viewpoints are difficult to identify, integrate and communicate to decision-makers.

If developed countries struggle with the methods to truly represent impact significance and acceptability, how much more difficult is it in South Africa with its First-Third-World socio-economic dynamics, including the multiplicity of cultures (South Africa has eleven official languages).

8. References

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APPENDIX A:

EXAMPLE OF THRESHOLDS OF SIGNIFICANCE FOR NOISE EXPOSURE

The following description of the noise guidelines used in determining the significance of noise-related impacts in the City of Mountain View, California has been sourced from the CEQA (California Environmental Quality Act) Technical Advice Series (1994).

BACKGROUND

Sound is a pressure variation that can be detected by the human ear. Undesired sound is defined as noise. Noise intensity or loudness is measured on a decibel scale where an increase of ten decibels equals a doubling of the noise level. Ordinary conversation is about 60 decibels. The City of Mountain View has established noise guidelines for each of its land use categories, and has assigned levels for indoor and outdoor activities. The decibel intervals are based on sound levels that do not interfere with an individual's activities or threaten a person's physical and psychological well-being. Noise that exceeds these standards may require some type of mitigation, such as perimeter sound walls or double-paned windows.

The City of Mountain View's noise guidelines are expressed in terms of dB(A)Ldn, which is a measurement of the intensity of sound (dB), weighted by frequency to correspond with the way humans perceive sound (A), and averaged over the period that the measurement was taken (Ld for daytime measurements, and Ln for night-time measurements). The dB(A)Ldn measurements assign an automatic ten decibel penalty to night-time measurements, thus eliminating the need to have separate standards for day and night.

THRESHOLDS OF SIGNIFICANCE

Significant noise impact is defined as one that substantially increases the ambient noise levels for adjoining areas. The following guidelines are used in determining the significance of noise-related impacts for the City of Mountain View.

Land Use

When considering the application or reclassification of land use designations in the City of Mountain View, existing noise levels in the subject area are compared with appropriate noise levels for the proposed land use. For example, if the City received an application to redevelop an industrial property for residential purposes, the noise contour map would be consulted to determine if exterior noise in the vicinity of the project exceeds the 55 decibel standard for residential land users. If so, a noise impact study is requested to verify existing noise levels and identify special noise insulation features that maintain noise standards. Noise impacts are considered significant if they exceed the noise guidelines listed in Figure 3 below.

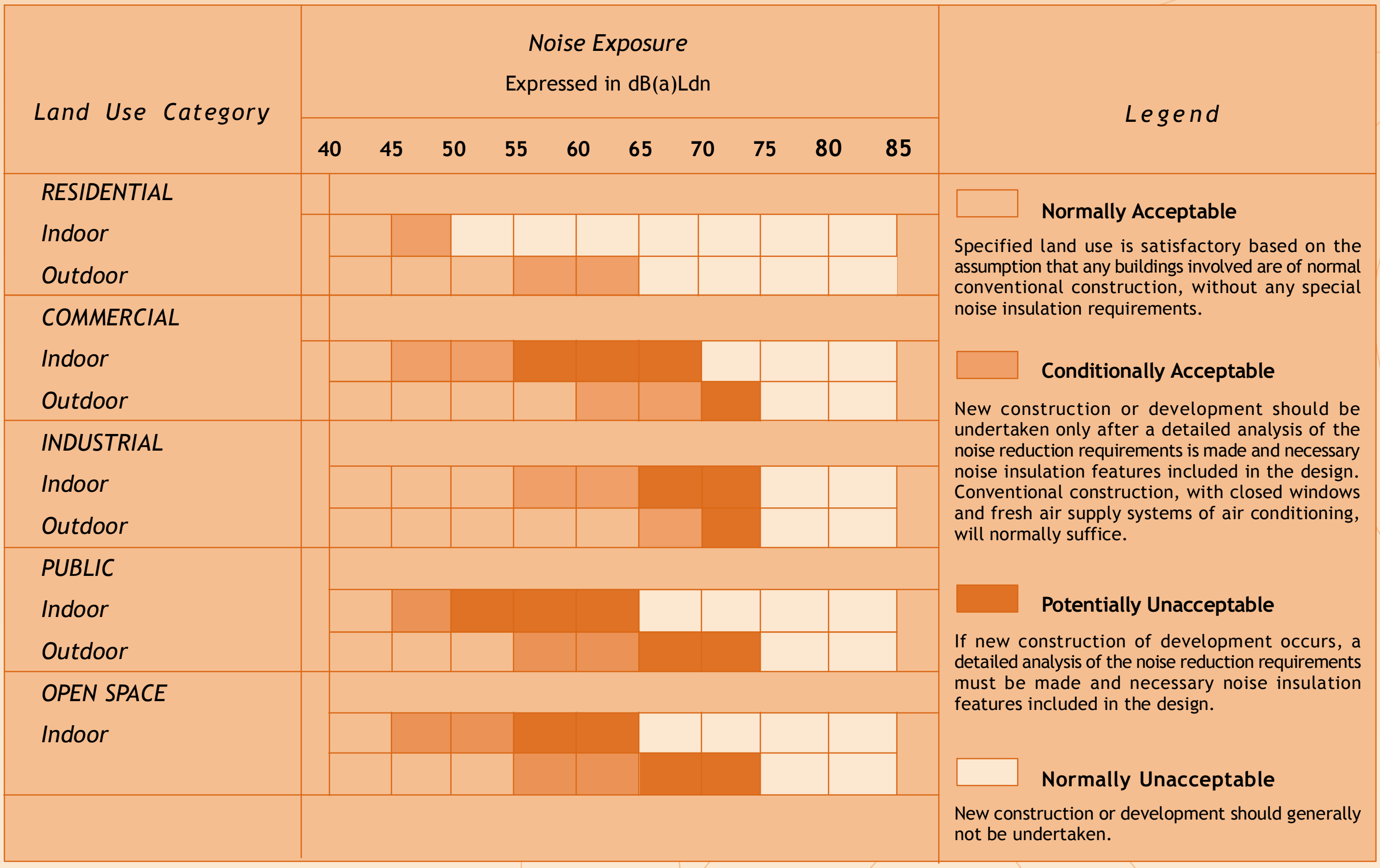
Residential land uses

Residential land uses include family homes, apartments, mobile homes and long-term medical care facilities. Residential land uses are considered sensitive noise receptors and have a low threshold of significance. Where residential land uses are proposed with exterior noise levels exceeding 55 decibels, a noise study may be required to investigate special noise insulation features that maintain interior noise levels at or below 45 decibels when doors and windows are closed. Noise levels exceeding 65 decibels in outdoor areas and 50 decibels in interior areas are usually considered significant unless mitigated.

Commercial land uses

Commercial land uses include personal services, retail outlets, entertainment facilities, restaurants, offices and hotels. Where commercial land uses are proposed with exterior noise levels exceeding 60 decibels, a noise study may be required to investigate special noise insulation features that maintain interior noise levels at or below 45 decibels when doors and windows are closed. Noise levels in excess of 70 decibels in outdoor areas and 55 decibels for interior areas are usually considered significant unless mitigated.

Figure 3: Thresholds of significance for noise exposure



Industrial land uses

Industrial land uses include manufacturing, processing, assembling, warehousing, wholesale and other related industries. Where industrial land uses are proposed with exterior noise levels exceeding 65 decibels, a noise study may be required to investigate special noise insulation features that maintain interior noise levels at or below 55 decibels when doors and windows are closed. Noise levels in excess of 70 decibels in outdoor areas and 65 decibels for interior areas are usually considered significant unless mitigated.

Public land uses

Public land uses include schools, libraries, churches, hospitals, civic buildings and related structures. Public land uses, like residential land uses, are considered sensitive noise receptors and have a low threshold of significance. Where public land uses are proposed with exterior noise levels exceeding 55 decibels, a noise study may be required to investigate special noise insulation features that maintain interior noise levels at or below 45 decibels when doors and windows are closed. Noise levels exceeding 65 decibels in outdoor areas and 50 decibels in interior areas are usually considered significant unless mitigated.

Open Spaces

Open spaces include parks, playgrounds, wildlife habitats and agricultural areas. Where open space land uses are proposed with exterior noise levels exceeding 55 decibels, a noise study may be required to investigate special noise insulation features that maintain interior noise levels at or below 45 decibels when doors and windows are closed. Noise levels exceeding 65 decibels in outdoor areas and 55 decibels in interior areas are usually considered significant unless mitigated.

Land use compatibility

When considering applications for new projects, the noise impacts of the proposed project on adjacent land uses are considered. For example, exterior noise levels of up to 70 decibels may be acceptable for an industrial facility, if the noise is restricted to industrial areas. Where noise from an industrial facility crosses into other land uses, the facility is required to meet the noise standards of the applicable land use. The standards listed above are designed to ensure land use compatibility. Noise levels that are projected to exceed these standards are considered significant environmental impacts, unless mitigated. Appropriate mitigation measures may involve construction of a solid masonry wall along one or more property lines and ensuring that all machinery and industrial equipment are adequately screened or muffled.

9. Glossary

Definitions

Affected environment

Those parts of the socio-economic and biophysical environment impacted on by the development.

Affected public

Groups, organizations and/or individuals who believe that an action might affect them.

Alternative proposal

A possible course of action, in place of another, that would meet the same purpose and need. Alternative proposals can refer to any of the following, but are not necessarily limited to these:

- alternative sites for development
- alternative projects for a particular site
- alternative site layouts
- alternative designs
- alternative processes
- alternative materials.

In IEM the so-called "no-go" alternative also requires investigation.

Authorities

The national, provincial or local authorities that have a decision-making role or interest in the proposal or activity. The term includes the lead authority, as well as other authorities.

Baseline

Conditions that currently exist. Also called "existing conditions".

Baseline information

Information derived from data that:

- records the existing elements and trends in the environment; and
- records the characteristics of a given project proposal.

Decision-maker

The person(s) entrusted with the responsibility for allocating resources or granting approval to a proposal.

Decision-making

The sequence of steps, actions or procedures that result in decisions, at any stage of a proposal.

Environment

The surroundings within which humans exist and that are made up of:

i. the land, water and atmosphere of the earth;

ii. micro-organisms, plant and animal life;

iii. any part or combination of (i) and (ii) and the interrelationships among and between them; and

iv. the physical, chemical, aesthetic and cultural properties and conditions of the foregoing that influence human health and well-being. This includes the economic, cultural, historical, and political circumstances, conditions and objects that affect the existence and development of an individual, organism or group.

Environmental Assessment (EA)

The generic term for all forms of environmental assessment for projects, plans, programmes or policies. This includes methods/tools such as EIA, strategic environmental assessment, sustainability assessment and risk assessment.

Environmental consultant

Individuals or firms that act in an independent and unbiased manner to provide information for decision-making.

Environmental Impact Assessment (EIA)

A public process that is used to identify, predict and assess the potential environmental impacts of a proposed project on the environment. The EIA is used to inform decision-making.

Fatal flaw

Any problem, issue or conflict (real or perceived) that could result in proposals being rejected or stopped.

Impact

The positive or negative effects on human well-being and/or on the environment.

Integrated Environmental Management (IEM)

A philosophy that prescribes a code of practice for ensuring that environmental considerations are fully integrated into all stages of the development and decision-making process. The IEM philosophy (and principles) is interpreted as applying to the planning, assessment, implementation and management of any proposal (project, plan, programme or policy) or activity - at local, national and international level - that has a potentially significant effect on the environment. Implementation of this philosophy relies on the selection and application of appropriate tools to a particular proposal or activity. These may include environmental assessment tools (such as strategic environmental assessment and risk assessment), environmental management tools (such as monitoring, auditing and reporting) and decision-making tools (such as multi-criteria decision support systems or advisory councils).

Interested and affected parties (I&APs)

Individuals, communities or groups, other than the proponent or the authorities, whose interests may be positively or negatively affected by a proposal or activity and/or who are concerned with a proposal or activity and its consequences. These may include local communities, investors, business associations, trade unions, customers, consumers and environmental interest groups. The principle that environmental consultants and stakeholder engagement practitioners should be independent and unbiased excludes these groups from being considered stakeholders.

Lead authority

The environmental authority at national, provincial or local level entrusted, in terms of legislation, with the responsibility for granting approval to a proposal or allocating resources, and for directing or coordinating the assessment of a proposal that affects a number of authorities.

Mitigate

The implementation of practical measures to reduce adverse impacts or enhance beneficial impacts of an action.

Non-governmental organizations (NGOs)

Voluntary environmental, social, labour or community organizations, charities or pressure groups.

Proponent

Any individual, government department, authority, industry or association proposing an activity (e.g. project, programme or policy).

Proposal

The development of a project, plan, programme or policy. Proposals can refer to new initiatives or extensions of, and revisions to existing ones.

Public

Ordinary citizens who have diverse cultural, educational, political and socio-economic characteristics. The public is not a homogeneous and unified group of people with a set of agreed common interests and aims. There is no single public. There are a number of publics, some of whom may emerge at any time during the process, depending on their particular concerns and the issues involved.

Roleplayers

The stakeholders who play a role in the environmental decision-making process. This role is determined by the level of engagement and the objectives set at the outset of the process.

Scoping

The process of determining the spatial and temporal boundaries (i.e. extent) and key issues to be addressed in an environmental assessment. The main purpose of scoping is to focus the environmental assessment on a manageable number of important questions. Scoping should also ensure that only significant issues and reasonable alternatives are examined.

Screening

A decision-making process to determine whether or not a development proposal requires environmental assessment, and if so, what level of assessment is appropriate. Screening is initiated during the early stages of the development of a proposal.

Significant/significance

Significance can be differentiated into impact magnitude and impact significance. Impact magnitude is the measurable change (i.e. intensity, duration and likelihood). Impact significance is the value placed on the change by different affected parties (i.e. level of significance and acceptability). It is an anthropocentric concept, which makes use of value judgements and science-based criteria (i.e. biophysical, social and economic). Such judgement reflects the political reality of impact assessment in which significance is translated into public acceptability of impacts.

Stakeholders

A subgroup of the public whose interests may be positively or negatively affected by a proposal or activity and/or who are concerned with a proposal or activity and its consequences. The term therefore includes the proponent, authorities (both the lead authority and other authorities) and all interested and affected parties (I&APs). The principle that environmental consultants and stakeholder engagement practitioners should be independent and unbiased excludes these groups from being considered stakeholders.

Stakeholder engagement

The process of engagement between stakeholders (the proponent, authorities and I&APs) during the planning, assessment, implementation and/or management of proposals or activities. The level of stakeholder engagement varies, depending on the nature of the proposal or activity and the level of commitment by stakeholders to the process. Stakeholder engagement can therefore be described by a spectrum or continuum of increasing levels of engagement in the decision-making process. The term is considered to be more appropriate than the term "public participation".

Stakeholder engagement practitioner

Individuals or firms whose role it is to act as independent, objective facilitators, mediators, conciliators or arbitrators in the stakeholder engagement process. The principle of independence and objectivity excludes stakeholder engagement practitioners from being considered stakeholders.

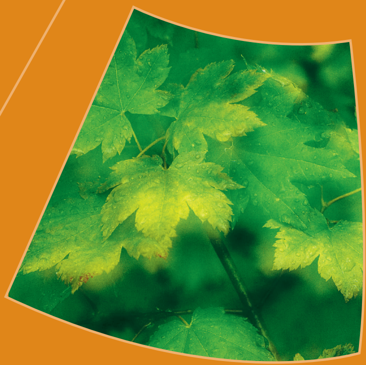
Abbreviations

CBO	Community-based Organization
EA	Environmental Assessment
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
EMS	Environmental Management Systems
I&AP	Interested and Affected Party
IEM	Integrated Environmental Management
NGO	Non-governmental Organization
SEA	Strategic Environmental Assessment

Notes

Notes

KIC CONCEPTUAL DESIGN AND BRANDING



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