Topic 6—Impact analysis

Objectives

To provide an overview of the tools and methods used to identify, predict and evaluate different types of impacts.

To understand how these methods can be used in EIA practice, and their relative strengths and weaknesses.

Relevance

A large kit of tools and methods is used to aid the systematic identification, prediction and evaluation of impacts. Those involved in EIA need an understanding of 'how' and 'when' different methods can be appropriately used.

Timing

Four hours (not including training activity)

Important note to trainers

You should design your presentation with the needs and background of participants in mind, and concentrate on those sections most relevant to your audience. The session presentation timings are indicative only.

Time taken for the training activities can vary enormously depending on the depth of treatment, the existing skills and knowledge of participants and the size of the group.

☑ Information checklist

Obtain or develop the following, as appropriate:

- ❑ a resource bank of locally appropriate impact identification and prediction methods (e.g. checklists, matrices, overlays etc);
- ❑ examples of their application to actual proposals;
- ❑ a table of the different types of environmental impacts that have been identified in local projects, especially impacts that are particular to the region;
- ❑ examples of other impact analysis methods that can be used to assess social, health and economic impacts;
- ❑ examples of methods used to make judgements about impact significance;
- ❑ examples of EIAs in which a range of alternatives were examined, identifying, where possible, methods that were used to compare and choose between them;
- ❑ copies of any research focused on the use of methods for impact identification, prediction and evaluation of significance;
- ❑ contact names and telephone numbers of people, agencies, organisations and environmental information/data resource centres able to provide assistance in relation to impact analysis; and
- ❑ other resources that may be available such as courses in specific analytical or methodological techniques, videos, journal articles, computer programmes, lists of speakers, and case studies.

Session outline

Welcome participants to the session by introducing yourself and getting them to introduce themselves. Outline the overall coverage of the session, its objectives, and why they are important.

This topic is structured to reflect the three phases of impact analysis that are undertaken as part of the EIA process:

- identifying more specifically the impacts to be investigated in detail;
- predicting the characteristics of the main impacts; and
- evaluating the significance of the residual impacts that cannot be mitigated.

Impact analysis is the technical heart of the EIA process. Depending on requirements, EIA trainers may focus selectively on the above phases, going only into the detail on methods and tools that is appropriate. It is expected that only those groups requiring a comprehensive introduction to impact analysis will work through the whole topic.

Review the screening and scoping phases of the EIA process linking them to the impact assessment stage of the process. (Refer as necessary to Topic 4 – *Screening* and Topic 5 – *Scoping* for information on screening and scoping).

The screening phase of the EIA determines whether or not an EIA is required for a particular proposal. The scoping phase identifies the important issues that should be investigated in detail (making sure that time and money is not wasted investigating issues that are not of concern).

The next stage of the EIA process is when a detailed assessment is undertaken to forecast the characteristics of the main potential impacts. Known as impact analysis, this stage can be broken down into three overlapping phases:


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- *identification* — to specify the impacts associated with each phase of the project and the activities undertaken;
- *prediction* — to forecast the nature, magnitude, extent and duration of the main impacts; and
- *evaluation* — to determine the significance of residual impacts i.e. after taking into account how mitigation will reduce a predicted impact.

Impact identification and prediction are undertaken against an environmental baseline, often delineated by selected indices and indicators (e.g. air/water, noise, ecological sensitivity, biodiversity). The collection of baseline information and the relevant biophysical and socio-economic conditions begins during screening and continues in scoping. Often, additional baseline data will need to be collected to establish reference points for impact identification and prediction. These requirements should be identified in the Terms of Reference.

Outline how the environment and sustainability agendas have widened the range of impacts that are usually considered during EIA beyond those that are purely biophysical. Provide brief examples of the range of impacts that are currently considered in local EIA of proposals.

Early EIAs focused only or primarily on impacts on the natural or biophysical environment (such as effects on air and water quality, flora and fauna, noise levels, climate and hydrological systems). However, over time, increased consideration has been given to social, health and economic impacts. This trend has been driven partly by public involvement in the EIA process. It is reflected by the evolving definition of the term 'environment' in EIA legislation, guidance and practice.


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In many EIA systems, a broad definition of 'environment' is adopted. This can include effects on:

- human health and safety;
- flora, fauna, ecosystems and biological diversity;
- soil, water, air, climate and landscape;
- use of land, natural resources and raw materials;
- protected areas and designated sites of scientific, historical and cultural significance;
- heritage, recreation and amenity assets; and
- livelihood, lifestyle and well being of those affected by a proposal.

Depending on the EIA system, some or all of these impacts may require analysis and evaluation. Often, however, health, social and other non-biophysical impacts are either not considered or are inadequately addressed. An alternative approach is to undertake separate, but parallel, assessments of social, health and other impacts when they are considered to be particularly important for decision-making and not adequately addressed by EIA or other similar processes (such as risk assessment). The preferable approach is to undertake an integrated analysis (see Topic 15 –*Future directions)*.

Impact identification

Outline the need for a systematic and reproducible method of identifying impacts and their causes. Note that this should begin during scoping. Then introduce impact identification methods and discuss each of them in turn.

A logical and systematic approach needs to be taken to impact identification. The aim is to take account of all of the important environmental/project impacts and interactions, making sure that indirect and cumulative effects, which may be potentially significant, are not inadvertently omitted.

This process begins during screening and continues through scoping, which identifies the key issues and classifies them into impact categories for further study. In the next phase, the likely impacts are analysed in greater detail in accordance with terms of reference specifically established for this purpose (see Topic 5 – *Scoping*).

Over time, a number of EIA methodologies and tools have been developed for use in impact identification. (Some of them are also useful tools for presenting the results of the EIA or assigning significance, as discussed later in this topic). In practice, relatively simple methodologies and tools are applied to impact identification (as compared to more complex, data-demanding methods which may be used in impact prediction). Experience indicates these simple methods are of proven value for undertaking a systematic approach to impact identification.

The most common formal methods used for impact identification are:

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- checklists;
- matrices;
- networks;
- overlays and geographic information systems (GIS);
- expert systems; and
- professional judgement

Checklists

(Note that OHPs 4 and 5 should be used only to indicate the structure of checklists. If you wish to discuss these examples in detail ensure that participants have copies of Handouts 6–1 and 6-2.)

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Checklists annotate the environmental features or factors that need to be addressed when identifying the impacts of projects and activities. They can vary in complexity and purpose, from a simple checklist to a structured methodology or system that also assigns significance by scaling and weighting the impacts (such as the Battelle Environmental Evaluation System). Both simple and descriptive checklists can be improved and adapted to suit local conditions as experience with their use is gained.

6-1

Checklists provide a systematized means of identifying impacts. They also have been developed for application to particular types of projects and categories of impacts (such as dams or road building). Sectoral checklists often are useful when proponents specialise in one particular area of development. However, checklists are not as effective in identifying higher order impacts or the inter-relationships between impacts, and therefore, when using them, consider whether impacts other than those listed may be important. An example of a sector-based checklist can be found in Handout 6-1.

Matrices

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A matrix is a grid-like table that is used to identify the interaction between project activities, which are displayed along one axis, and environmental characteristics, which are displayed along the other axis. Using the table, environment-activity interactions can be noted in the appropriate cells or intersecting points in the grid. 'Entries' are made in the cells to highlight impact severity or other features related to the nature of the impact, for instance:

- ticks or symbols can identify impact type (such as direct, indirect, cumulative) pictorially;
- numbers or a range of dot sizes can indicate scale; or
- descriptive comments can be made.

6-2

An early, well-known example is the Leopold interaction matrix. This is a comprehensive matrix, which has 88 environmental characteristics along the top axis and 100 project actions in the left hand column. Potential impacts are marked with a diagonal line in the appropriate cell and a numerical value can be assigned to indicate their magnitude and importance. Use of the Leopold matrix is less common than its adaptation to develop other, less complex matrices. An example can be found in Handout 6-2.

Networks

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Networks illustrate the cause-effect relationship of project activities and environmental characteristics. They are, therefore, particularly useful in identifying and depicting secondary impacts (indirect, cumulative, etc). Simplified networks, used in conjunction with other methods, help to ensure that important second-order impacts are not omitted from the investigation. More detailed networks are visually complicated, time-consuming and

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difficult to produce unless a computer programme is used for the task. However, they can be a useful aid for establishing 'impact hypotheses' and other structured science-based approaches to EIA. An example of an impact network can be found at Handout 6-3.

Overlays and geographic information systems

Overlays can be used to map impacts spatially and display them pictorially. The original overlay technique, popularised by McHarg, is an environmental suitability analysis in which data on topographic features, ecological values and resource constraints are mapped onto individual transparencies and then aggregated into a composite representation of potential impacts. This approach is useful for comparing site and planning alternatives, for routing linear developments to avoid environmentally sensitive areas and for landscape and habitat zoning at the regional level. Disadvantages of this approach relate to the lack of precision in differentiating the likelihood and magnitude of impacts and relating them to project actions. Also, the overlay process can become cumbersome in its original form.

A modern version of the overlay method is the computer-based geographical information system (GIS). In simple terms, a GIS stores, retrieves, manipulates and displays environmental data in a spatial format. A set of maps or overlays of a given area provide different types of information and scales of resolution. The use of GIS for EIA purposes is not as widespread as commonly imagined. The main drawbacks are the lack of appropriate data and the expense of creating a usable system. However, the potential application of GIS to EIA is widely acknowledged and its use is expected to increase in the future, particularly to address cumulative effects.

Expert systems

Expert or knowledge-based systems are used to assist diagnosis, problem solving and decision-making. A number of such computerised systems have been developed for use in EIA, primarily at the early stages of the process. For example, screening and scoping procedures have been automated using a number of rules and a data system, which encodes expert knowledge and judgement. The user has to answer a series of questions that have been systematically developed to identify impacts and determine their 'mitigability' and significance. Based on the answer given to each question, the expert system moves to the next appropriate question.

Like GIS systems, expert systems are an information-intensive, high-investment method of analysis. As such, they are limited in their current use and application, especially by many developing countries. However, they also have the potential to be a powerful aid to systematic EIA in the future, not least because they can provide an efficient means of impact identification.

Expert systems also can be updated by building in experience gained over time.

Professional judgement

Although not strictly a formal method, professional judgement or expert opinion is widely used in EIA. Knowledge and expertise gained in EIA work can be used to systematically develop data banks, technical manuals and expert systems, thereby assisting in future projects. The successful application of the formal methods of impact identification described above rests upon professional experience and judgement. Expert opinion and professional judgement can be focused by the use of interactive methods, such as Delphi techniques and science workshops, to identify impacts, model cause-effect relationships and establish impact hypotheses.

Review the factors that should be considered when choosing an impact identification method and outline how the choice could be made in a given situation.

No single impact identification methodology is suited to use on all occasions; nor is it necessary to use only one method at a time. Combining the useful aspects of two different techniques may be the best approach to take. As noted above, EIA checklists, matrices and networks can have added value when applied by experts in an interactive process. Note, also that some of the methods perform other functions that may be useful to the EIA team (e.g. the Battelle checklist can be used to determine significance).

The choice of methodology can depend upon a number of factors including:


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- the type and size of the proposal;
- the type of alternatives being considered;
- the nature of the likely impacts;
- the availability of impact identification methods;
- the experience of the EIA team with their use; and
- the resources available – cost, information, time, personnel.

A word of caution

When using impact identification methods (such as checklists or matrices) developed by others, care should be taken to ensure that these are suitable for your purpose. A summary of the main advantages and disadvantages of these methods is given in the table below. In reviewing them, particular attention should be given to environmental features that are distinctive or extreme to the region in which the project is proposed (e.g. flood, drought, temperature, seismic activity, land instability, disease vectors, etc).

Table 1: Main advantages and disadvantages of impact identification methods

	ADVANTAGES	DISADVANTAGES
Checklists	• easy to understand and use • good for site selection and priority setting • simple ranking and weighting	• do not distinguish between direct and indirect impacts • do not link action and impact • the process of incorporating values can be controversial
Matrices	• link action to impact • good method for displaying EIA results	• difficult to distinguish direct and indirect impacts • have potential for double-counting of impacts
Networks	• link action to impact • useful in simplified form for checking for second order impacts • handles direct and indirect impacts	• can become very complex if used beyond simplified version
Overlays	• easy to understand • focus and display spatial impacts • good siting tool	• can be cumbersome • poorly suited to address impact duration or probability
GIS and computer expert systems	• excellent for impact identification and spatial analysis • good for 'experimenting'	• heavy reliance on knowledge and data • often complex and expensive


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Impact analysis/prediction

Provide a general introduction to the analysis and prediction of impacts. Note that predictive studies often require expert knowledge.

Once all the important impacts have been identified, their potential size and characteristics can be predicted. Impact prediction or forecasting is a technical exercise. It utilises physical, biological, socio-economic and cultural data to estimate the likely characteristics and parameters of impacts (e.g. magnitude, spatial occurrence etc.). A range of methods and techniques may be employed. These can be a continuum from simple methods for impact identification (described earlier) to advanced methods, often involving the application of mathematical models. Examples of commonly used impact prediction tools are given in Table 1.

In many cases, this work will need to be carried out by specialists in the disciplines involved or in the application of models and techniques. However, the sophistication of prediction methods used should be in proportion to the scope of the EIA and relevant to the importance of the particular impact. Specialists may become involved in research and methodology that is of interest to them rather than directly related to the impact of the proposal. This can be avoided by making sure the programme of research and data collection is focused on addressing the concerns outlined in the terms of reference.

Where possible, impacts should be predicted quantitatively. This makes comparison among alternatives and with baseline conditions easier and facilitates impact monitoring and auditing later in the EIA process. If quantification is difficult, then it is important to use methods that allow the impacts to be estimated and compared systematically. Rating techniques, for example, can be used to assist impact estimation (as well as assign values) where there is insufficient data, a high level of uncertainty and/or limited time and money (all common in many EIAs). The results of qualitative analysis should be communicated clearly, for example in the form of a range of graded 'dot sizes' presented in a table.

Sometimes there are few or no alternatives to qualitative description, as is in the case of scenic quality, amenity, sense of place or other landscape characteristics. Wherever possible, description should be based on some type of classification and the impacts summarised in appropriate form, for example, maps, cross-sections and/or photomontages.

Briefly discuss the interaction that must occur among those undertaking the impact studies and between these people and the project designers and managers.

In most cases, an multi-disciplinary team will conduct the EIA study. The terms of reference will dictate the composition of the team and the knowledge base and skills required. When organising different specialists to address a common task or problem, it is important for the study manager to establish a clear process of communication with, and amongst, them. This should extend to communication with those responsible for overall project management, as it is often possible for design changes to be incorporated to reduce environmental impacts well before the production of the EIA report. This can result in savings of money and time to the proposal in the long run. (For further information on EIA project management refer to Topic 12 – *EIA project management*.)

Discuss the use of baseline studies and data collection. Show examples from local projects that have been well managed, and illustrate the importance of baseline data in EIA and project decision making.

Impact predictions are made against a ‘baseline’ established by the existing environment (or by its future state). Known as baseline studies, the collection of data on relevant biophysical, social and economic aspects provides a reference point against which the characteristics and parameters of impact-related changes are analysed and evaluated. In many cases, it is likely that the current baseline conditions will still exist when a project is implemented. However, certain projects have long lead times. In these cases, predictions may need to be made about the future state of the environment (the baseline condition for the no-development option).

When establishing a baseline, information is gathered on:


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- current environmental conditions;
- current and expected trends;
- effects of proposals already being implemented; and
- effects of other foreseeable proposals.

In practice, assembling baseline information can be time consuming and expensive. There can be difficulties in collecting appropriate and sufficient information. For example, there may be unforeseen circumstances in which the collection of data cannot be completed as required by the Terms of Reference. In such cases, the EIA team may have to revise the study strategy and/or use their judgement to make predictions. When this occurs it should be indicated in the EIA report with a short explanation of the reasons.

Specialised knowledge is usually required to oversee, and, where necessary, set limits on the collection of data required for impact analysis and monitoring. EIA project managers also need to ensure that time and effort is not spent on unnecessary data collection or that excessive space in the EIA report is not occupied by a description of baseline conditions. For example, the baseline chapter or section could be limited to not more than ten per cent of the total number of pages in the report. This issue is discussed further in Topic 8 – *Reporting*.

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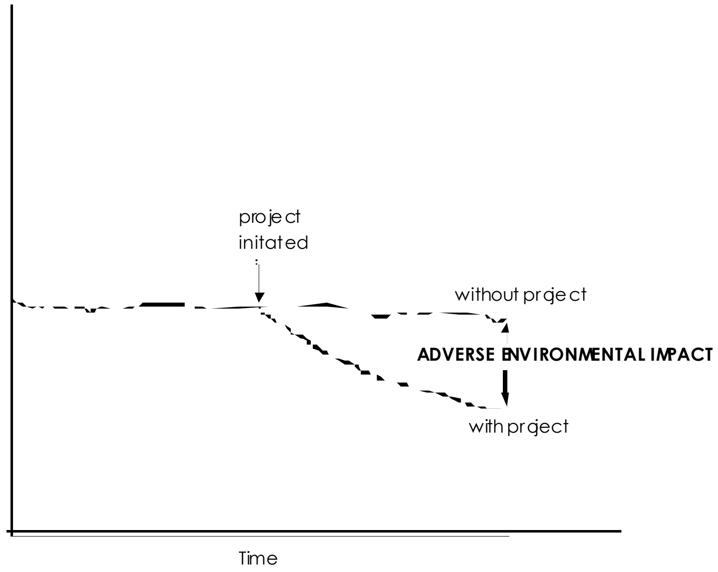

Source: Wathern (1988)

Figure 1: An environmental impact

Briefly define the word 'impact'. Outline the characteristics of impacts and discuss how these characteristics vary, noting their importance in prediction and decision-making. Emphasise that impacts can be positive or beneficial as well as adverse and that both types should be brought to the notice of decision-makers.

An impact or effect can be described as the change in an environmental parameter, which results from a particular activity or intervention. The change is the difference between the environmental parameter with the project compared to that without the project (as represented pictorially in the figure above). It is predicted or measured over a specified period and within a defined area.

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The characteristics of environmental impacts vary. Typical parameters to be taken into account in impact prediction and decision-making include:

- nature (positive, negative, direct, indirect, cumulative);
- magnitude (severe, moderate, low);
- extent/location (area/volume covered, distribution);
- timing (during construction, operation, decommissioning, immediate, delayed, rate of change);
- duration (short term, long term, intermittent, continuous);
- reversibility/irreversibility;

- likelihood (probability, uncertainty or confidence in the prediction); and
- significance (local, regional, global).

Nature

The most obvious impacts are those that are directly related to the proposal, and can be connected (in space and time) to the action that caused them. Typical examples of direct impacts are: loss of wetlands caused by agricultural drainage; destruction of habitat caused by forest clearance; relocation of households caused by reservoir impoundment; increased air particulate emissions caused by operation of a new power station, etc.

Indirect or secondary impacts are changes that are usually less obvious, occurring later in time or further away from the impact source. Examples of these types of impacts are: the spread of malaria as a result of drainage schemes that increase standing water and thereby create new vector habitat; bio-accumulation and bio-magnification of contaminants in the food chain through take up of agricultural pesticides; and anxiety, stress and community disruption associated with increased traffic volumes and noise caused by road development.

Cumulative effects, typically, result from the incremental impact of an action when combined with impacts from projects and actions that have been undertaken recently or will be carried out in the near or foreseeable future. These impacts may be individually minor but collectively significant because of their spatial concentration or frequency in time. Cumulative effects can accumulate either incrementally (or additively) or interactively (synergistically), such that the overall effect is larger than the sum of the parts.

Magnitude

Estimating the magnitude of the impact is of primary importance. Typically, it is expressed in terms of relative severity, such as major, moderate or low. Severity, as opposed to size, also takes account of other aspects of impact magnitude, notably whether or not an impact is reversible and the likely rate of recovery.

Extent/location

The spatial extent or zone of impact influence can be predicted for site-specific versus regional occurrences. Depending on the type of impact, the variation in magnitude will need to be estimated; for example, alterations to range or pattern of species or dispersion of air and water pollution plumes. This is much easier for direct impacts but can be attempted for other types of impacts.

Timing

Impacts arising from all of the stages of the life cycle of the project should be considered (i.e. during construction, operation and decommissioning). Some impacts will occur immediately, while others may be delayed, sometimes by many years. These impact characteristics should be noted in the EIA report.

Duration

Some impacts may be short-term, such as the noise arising from the operation of equipment during construction. Others may be long-term, such as the inundation of land during the building of a reservoir. Certain impacts such as blasting may be intermittent, whereas others, such as electromagnetic fields caused by power lines, may be continuous. Impact magnitude and duration classifications can be cross-referenced; for example, major but short term (less than one year), low but persistent (more than 20 years).

Significance

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The evaluation of significance at this stage of EIA will depend on the characteristics of the predicted impact and its potential importance for decision-making. Significance is usually attributed in terms of an existing standard or criteria of permissible change, for example as specified in a standard, policy objective or plan. This concept is discussed further later in this topic.

Table 2: Impact characteristic summary table

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IMPACT CHARACTERISTIC	IMPACT TYPE		
	air quality	health	etc.
nature			
magnitude			
extent/location			
timing			
duration			
reversibility			
likelihood (risk)			
significance			

Presentation of impact results

When preparing the EIA report a systematic format should be used to present information about impacts to decision-makers. The organisation and display of information is an integral part of certain predictive methodologies, such as the Battelle Environmental Evaluation System. In other cases, this framework may need to be designed separately. One possible format is an impact characteristic summary table above. Finally, reference should be made to the confidence limits in impact data, in probabilistic terms for quantitative judgements (e.g. 95 per cent) or in relative terms for qualitative judgements (reasonably high, best estimate, etc.).

Outline the range of methods that can be used in impact prediction, drawing attention to any local requirements at the appropriate stage of the discussion.


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Methods for predicting the characteristics of impacts include:

- 'best estimate' professional judgement;
- quantitative mathematical models;
- experiments and physical models; and
- case studies as analogues or points of reference.

These are discussed in general below. Specific examples of the use of predictive techniques can be found in the references listed at the end of this topic.

Professional judgement

As noted earlier, all methods of analysis involve professional judgement and the use of advanced tools and models will require expert knowledge.

Sole reliance on 'best estimate' professional judgement may be unavoidable when there is a lack of data to support more rigorous analyses or there is a lack of predictive methodology (as in the analysis of certain social impacts). Examples include the prediction of the effect of a water supply proposal on:

- the activities of women or community interaction; and
- the loss of a communal place or sacred site.

Such predictions should be made by specialists, who are familiar with the type of proposal, the geographic region and/or similar cases that are analogous to the situation. Where professional judgement is used without also employing other methods, the judgement and values of the specialist concerned may be open to challenge. Peer review and the use of agreed concepts and frameworks can be useful to corroborate findings.

Quantitative mathematical models

Quantitative models express cause-effect relationships as mathematical functions, derived from deterministic or probabilistic relationships. A number of such models are used in EIA to predict certain types of impacts, for example, on air, water, soil and habitat. More complex computer-based simulations are data demanding and often their use in EIA requires certain simplifying assumptions to be made.

The choice and use of quantitative models for impact prediction should be suited to the particular cause-effect relationship being studied; for example, transport and fate of oil spills, sediment loadings and fish growth and pesticide pollution of groundwater aquifers. Attention also needs to be given to the consistency, reliability and adaptability of models. Usually operational changes are made to the input conditions for the model to see how the outputs are affected. For instance, differences in air pollution can be calculated by changing the height of a stack or the rate of output of emissions.

Examples of the use of quantitative models include:

- air dispersion models to predict emissions and pollution concentrations at various locations resulting from the operation of a coal-fired power plant;
- hydrological models to predict changes in the flow regime of rivers resulting from the construction of a reservoir; and
- ecological models to predict changes in aquatic biota (e.g. benthos, fish) resulting from discharge of toxic substances.

Although traditionally this type of analysis has been carried out for physical impacts, there is increasing use of mathematical models to analyse biological, social/demographic and economic impacts.

When interpreting the results of quantitative mathematical models it should be remembered that all models are simplifications of the real world. They require the specialist to make a number of assumptions in both their development and their use. If these assumptions are inappropriate then there can be significant implications for the accuracy and usefulness of the output data. EIA project managers should ask all specialists carrying out mathematical analyses to clearly state the assumptions inherent in the use of their models, together with any qualifications to be placed on the results.

Experiments and physical models

Experiments and scale models can be used to test and analyse the effects of project-related activities and the effectiveness of proposed mitigation techniques. These methods have not been used extensively in impact prediction. However, they can be appropriate, depending upon the nature of the impact and the resources available, and providing certain cautions are remembered. When using the results of experiments or models, note that unpredicted outcomes can occur when the data are 'scaled up' to life size.

Experiments can be undertaken directly in the field or under laboratory conditions. Examples of their use include:

- the exposure of fish in a laboratory to concentrations of pollutants to determine mortality levels; and
- field trials of the effectiveness of different methods of erosion control.

Physical models can be built to predict the behaviour and effect of the actual project on the environment. For example, a physical model could be used to simulate changes to patterns of sand or sediment deposition resulting from port and harbour works.

Case studies

Reviewing case studies of projects in similar environments can inform and assist impact prediction and analysis. Comparisons will be especially helpful if impact monitoring and auditing data are available. Otherwise, the results obtained by a comparable use of EIA methodology should be consulted. Sometimes, relevant case material will not be readily accessible or available. In that event, there is a large body of general information on the impact 'footprints' of major types of projects, such as dams, roads, airports and power stations. However, this should be read with care as to its source and provenance.

Briefly discuss the importance of uncertainty in EIA and consider the value of undertaking a sensitivity analysis as part of the analysis of the impacts.

Uncertainty is a pervasive issue at all stages of the EIA process but is especially important for impact prediction. Put simply, uncertainty is a state of relative knowledge or ignorance. Where cause-effect relationships are 'known' and understood, however imperfectly, impacts can be forecast (or at least described). Certain impacts are unknown until they occur; for example, ozone depletion caused by release of CFCs and inter-species transmission of the human variant of Bovine Spongiform Encephalopathy (BSE) or 'mad cow' disease.


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Sources of uncertainty in impact prediction include:

- *scientific uncertainty* – limited understanding of an ecosystem (or community) and the processes that govern change;
- *data uncertainty* – restrictions introduced by incomplete or non-comparable information, or by insufficient measurement techniques; and
- *policy uncertainty* – unclear or disputed objectives, standards or guidelines for managing potential hazards and effects.

There are a number of approaches that can be used to address uncertainty in impact prediction, including:

- 'best' and 'worst' case prediction to illustrate the spread of uncertainty;
- attaching confidence limits to impact predictions; and
- sensitivity analysis to determine the effect of small changes in impact magnitude.

The relationship between impact, size and severity may not be linear. Small changes in impact magnitude may cause larger than expected increases or decreases in the severity of environmental change. Where necessary, an assessment should be made of the effect that small changes in the magnitude of the impact (say less than 10 per cent) have on the environment, particularly if significant or valued resources are potentially affected. This is referred to as a sensitivity analysis.

Briefly discuss the types of considerations introduced into impact analysis by three of the non-biophysical impacts frequently considered during integrative EIA – social, health and economic.

A broader range of impacts and interrelationships are now routinely integrated into EIA. These include the social, economic and health aspects of environmental change. In comparison to biophysical impacts, less experience has been gained in analysing these and other non-biophysical impacts. However, this situation is changing. The discussion below serves as a brief introduction to social, health and economic impacts. For more detailed coverage of the analysis of these and other impacts refer to the references listed at the end of this chapter.

Social impact assessment

People are an integral part of the environment. Human activity alters the biophysical environment and, in turn, these impacts are translated into social effects. In many EIA systems the immediate and direct social impacts of a proposal always should be analysed as an integral component of an EIA.

Social impacts include changes that affect individuals, groups, communities and populations as well as the interactions between them. They are alterations in the way people live, work, play, relate to each other and organise their communities and institutions to meet their needs and guide their collective actions, as well as changes in their characteristic values, beliefs, norms, traditions and perceptions of quality of life and well being.


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Social impacts can be divided into four main types:

- *demographic impacts* such as changes in population numbers and characteristics (such as sex ratio, age structure, in-and-out migration rates and resultant demand for social services, hospital beds, school places, housing etc);
- *cultural impacts* including changes to shared customs, traditions and value systems (e.g. language, dress, religious beliefs and rituals) archaeological, historical and cultural artefacts and to structures and environmental features with religious or ritual significance;
- *community impacts* including changes in social structures, organisations and relationships and their accompanying effect on cohesion, stability, identity and provision of services; and

- *socio-psychological impacts* including changes to individual quality of life and well being, sense of security or belonging and perceptions of amenity or hazard.

Often, local people are not the beneficiaries of proposed development. Rather they bear the brunt of the adverse impacts. These effects are especially acute in developing countries when projects displace people whose security and subsistence depends on the land and resources that will be affected. World Bank environmental and social assessment procedures give particular attention to the impact on indigenous peoples and other vulnerable ethnic and cultural groups whose lifestyle, value and tenure systems may be disrupted or lost.

A comprehensive social impact assessment (SIA) will be required in such cases. In other circumstances, adding a relevant specialist to the EIA team may suffice to address social impacts. However, it should be emphasised that there is little consensus on the social impacts that should be included as part of an EIA process. Other than agreeing that the scope is too limited, SIA practitioners themselves differ on the aspects to be studied and the framework within which they should be analysed. Further information on this subject can be found in Topic 13 – *Social Impact Assessment.*

Health impacts

Health impacts can be a significant aspect of certain types of development. These impacts can be beneficial as well as adverse; for example, water infrastructure projects eradicate or drastically reduce the occurrence of cholera, diarrhea and other gastro-intestinal diseases that are endemic in less developed countries. However, adverse health impacts can also occur as a result of development projects, either directly from changes to the biophysical environment (such as exposure to pollutants) or indirectly as a secondary result of other changes; for example, the creation of habitat conditions favourable to the spread or intensification of disease vectors, such as mosquitoes (malaria) or water snails (schistosomiasis).

To date, insufficient attention has been given to health impacts in comparison to coverage given to biophysical or even other social impacts. In many cases, health impact assessment (HIA) is carried out separately and independently; for example in the chemical, nuclear and other hazardous industries. The World Health Organisation, the World Bank and other international agencies recommend that, where necessary and appropriate, HIA should be integrated with the EIA process. Both use similar information, approach and methods; for example, when identifying the health and environmental impacts of exposure to air particulate emissions from a proposed power plant.

Table 3: Examples of health impacts by sector

	Communicable disease	Non communicable disease	Nutrition	Injury	Psychosocial disorder and loss of well-being
Mining	Tuberculosis	Dust induced lung disease		Crushing	Labour migration
Agriculture	Parasitic infections	Pesticide poisoning	Loss of subsistence		
Industry		Poisoning by pollutants		Occupational injury	Disempower-ment
Forestry			Loss of food production	Occupational injury	
Dams and irrigation schemes	Water borne diseases	Poisoning by pollutants	Increased food production	Drowning	Involuntary displacement
Transportation	HIV/Aids	Heart disease		Traffic injury	Noise and induced stress
Energy		Indoor air pollution		Electromagnetic radiation	Community displacement

Source: Birley draft materials prepared for World Health Organisation (2000)


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Certain proposals can also increase the risk of accidental death and injury to the workforce and the public. Examples of occupational and public health and safety issues include exposure to increased traffic levels introduced by road building or to dangerous and hazardous industries, such as those involving the processing, storage and/or transportation of flammable materials or toxic gases. In these situations, a risk assessment should be undertaken as part of an EIA to determine the probability of an accident or malfunction occurring and the likely consequences.

The table above illustrates some of the health hazards and impacts associated with development proposals from different sectors.

Economic and fiscal impacts

Invariably, the economic feasibility of a major proposal will be subject to cost-benefit analysis (CBA). In addition, specific economic and fiscal impacts of a development proposal may need to be considered as part of the EIA process, for example where they have a direct bearing on social and health impacts.

Typically, economic impact assessment is carried out to predict project-related changes in employment (e.g. new job requirements in relation to the local labour market), per capita income (e.g. locally retained versus exported remittances) and levels of business activity (e.g. positive and negative effects of the project on local enterprises). Often, economic impacts cause social impacts, for example, if there is a large influx of temporary workers into a local community during the project construction phase of project development. Such 'boomtown' conditions may threaten community cohesion and health and strain services and access to them by local residents.

Fiscal impacts accrue from changes in the costs and revenues of the various government sectors. These changes typically occur as the result of a proposal causing relatively large increases in population and the requirement for additional capital expenditures on local infrastructure and facilities provided by government (e.g. health services, roads, sewerage etc.). A common issue is that of 'front-end financing' – i.e., whether or not expenditures will increase quicker than revenues in the early phase of project implementation.

If that happens, it creates deficit and cash flow difficulties, often with resulting shortfalls or 'bottlenecks' in the provision of basic services. This leads, in turn, to the overloading of infrastructure, such as water supply and sewerage, and consequent environmental and social impacts. Resolving these problems can be especially difficult if the revenues from a project are received in one jurisdiction and the costs are borne in another.

The factors that typically affect economic and fiscal impacts are identified in the box below. A number of methods can be used to predict these impacts. For economic impacts, these include input-output and export-base models, which incorporate an income and employment multiplier to estimate the extra money that is injected and spent in the local economy, adjusting for any 'leakages'. The methods that can be employed for fiscal impact assessment differ substantially in the scope of costs and revenues addressed.

Box 1: Factors affecting economic and fiscal impacts


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Factors affecting economic impacts:

- duration of construction and operational periods
- workforce requirements for each period and phase of construction
- skill requirements (local availability)
- numbers employed and earnings
- raw material and other input purchases
- capital investment
- outputs
- the characteristics of the local economy

Factors affecting fiscal impacts:


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- size of investment and workforce requirements
- capacity of existing service delivery and infrastructure systems

- local/regional tax or other revenue raising processes
- likely demographic changes arising from project requirements (these need to be estimated during the assessment of social impacts)

Evaluation of impact significance

(Note: Impact significance is also discussed in Topic 4 – *Screening and* Topic 5 – *Scoping. These are the processes of identifying, respectively, whether or not and at what level EIA should be applied and which impacts require further investigation.)*

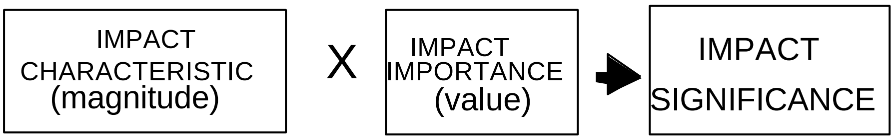

Figure 2: Calculating impact significance

Outline the importance of determining significance and discuss the approaches that can be used in impact evaluation.

Once the impacts have been analysed, they are evaluated to determine their significance. As noted earlier, the attribution of significance begins early, during screening and scoping, and extends throughout the EIA process. There is a gradually 'narrowing cone of resolution' on questions of impact significance as more complete information becomes available. Following impact identification and prediction, impact evaluation is the formal stage at which a 'test of significance' is made.

A systematic process should be followed in evaluating significance, distinguishing between 'as predicted' and 'residual' impacts. Step one involves evaluating the significance of 'as predicted' impacts to define the requirements for mitigation and other remedial actions (discussed in Topic 7 – *Mitigation and impact assessment*). Step two involves evaluating the significance of the 'residual' impacts, i.e. after mitigation measures are taken into account. This test is the critical measure of whether or not a proposal is likely to cause significant impacts. It is determined by the joint consideration of its characteristics (magnitude, extent, duration etc.) and the importance (or value) that is attached to the resource losses, environmental deterioration or alternative uses which are foregone (see Figure 2).

Impact evaluation is a difficult and contestable exercise, which cuts across the fluid boundary between 'facts' and values and between EIA and decision-making. First, a technical judgement must be made of the extent to which mitigation will reduce 'as predicted' impacts. Second, a subjective value must be placed on the significance of residual impacts, using criteria and tests described below. Finally, the attribution of significance usually will influence final approval and condition setting; for example by indicating whether or not the impact of a proposal is acceptable or not.

However, this latter task overlaps with the responsibility of the decision-maker. The environmental acceptability of a proposal and the terms and conditions to be attached to its implementation must be weighed against other economic and social factors by the decision-maker. Further information can be found in Topic 10 – *Decision-making.*

Discuss the criteria and measures of significance that are available and how they can be adapted to local application and use.

Evaluation of significance should take place against a framework of criteria and measures established for the purpose. These may be defined in EIA legislation and procedure; for example, by definition of what constitutes an environmental impact and guidance on how to determine significance. Often specified criteria are listed to aid such evaluation; for example, environmental standards and thresholds, protected and sensitive areas, valued ecological functions and components and resource and land use capabilities. Where this EIA guidance is not available, it can be developed separately by adapting criteria and measures that are relevant to local circumstances and the type of proposals reviewed.

EIA guidelines related to significance fall into two main categories:

- emissions based, comprising standards for air and water quality, noise etc.
- environmental quality based, comprising significance criteria for valued ecosystem components or similar attributes.

Emissions based standards will be jurisdiction specific (although certain standards may be internationally recognised) and provide an objective, technical means of determining significance; for example the anticipated residual impacts either do or do not exceed the relevant standard. However, reliance on standards suffers from certain deficiencies and limitations. The relevant technical standard may be the subject of disagreement or public concern (e.g. blood lead levels, traffic noise levels, electromagnetic field strengths). In many cases, an appropriate technical standard will not be available for the evaluation of significance (e.g. ecological, social and visual impacts).

Environmental quality based criteria or thresholds are qualitative, broadly drawn and require interpretation. In this context, impact evaluation is a subjective exercise, linking scientific criteria to social preferences (as discovered through public involvement or SIA methods) and relating them to the environment and community affected. Some of the impact identification techniques discussed earlier in this topic have built in scales or weightings (and hence values) based on prior experience. When applying them, the criteria should be modified to take account of local value systems and traditional practices.

Additionally, some countries and international agencies have established environmental sustainability criteria and environmental acceptability rules against which evaluation can be conducted. For example, the World Bank input and output guidelines are meant to ensure that each project does not exceed the regenerative and assimilative capacities of the receiving environment (see the box below). In practice, as the Bank acknowledges, there is considerable difficulty in applying these guidelines and it has augmented them with other environmental and social safeguards. Rules for environmental acceptability and their relationship to significance thresholds based on Western Australian experience are described in the companion box below.

Box 2: World Bank guidelines for environmental sustainability

Environmental Aspects of Bank Work, (OMS 2.36), para 9(a) states:

> The Bank endeavours to ensure that each project affecting renewable natural resources (e.g., as a sink for residues or as a source of raw materials) does not exceed the regenerative capacities of the environment.

Output Guide

> Waste emissions from a project should be within the assimilative capacity of the local environment to absorb without unacceptable degradation of its future waste absorptive capacity or other important services.

Input Guide

> Harvest rates of renewable resource inputs should be within regenerative capacity of the natural system that generates them; depletion rates of non-renewable resource inputs should be equal to the rate at which renewable substitutes are developed by human invention and investment.

Source: World Bank 1991


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Box 3: Examples of threshold tests for environmental acceptability

Level of acceptability	Potential impact threshold
Unacceptable	Exceeds legal threshold, e.g. quality standard
Unacceptable	Increases level of risk to public health and safety above qualitative or quantitative criteria (e.g. in some jurisdictions an increased risk of death of 1 in a million per year
Unacceptable	Extinction of biological species, loss of genetic diversity, rare or endangered species, critical habitat
Normally unacceptable	Conflict with existing environmental

	policies, land-use plans
Normally unacceptable	Loss of populations of commercial biological species
Normally unacceptable	Large-scale loss of productive capacity of renewable resources
May be acceptable only with minimization, mitigation, management	Avoidance of spread of biological disease, pests, feral animals, weeds
May be acceptable only with minimization, mitigation, management	Taking of rare or endangered species
May be acceptable only with minimization, mitigation, management	Some loss of threatened habitat
Normally acceptable	Some loss of populations and habitats of non-threatened species
Normally acceptable	Modification of landscape without downgrading special aesthetic values
Normally acceptable	Emissions demonstrably less than the carrying capacity of the receiving environment

Source: Sippe 1999

Aids and principles for evaluating significance


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Key reference points for evaluating significance include:

- environmental standards, guidelines and objectives;
- level of public concern (particularly over health and safety);
- scientific and professional evidence for:
  - loss/disruption of valued resource stocks and ecological functions;
  - negative impact on social values, quality of life and livelihood; and
  - foreclosure of land and resource use opportunities.


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Guiding principles for determining significance include:

- use procedure and guidance established by the jurisdiction;
- adapt other relevant criteria or identify points of reference from comparable cases;
- assign significance in a rational, defensible way;
- be consistent in the comparison of alternatives; and
- document the reasons for the judgements made.


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A test of significance can be applied by asking three questions:

- Are there residual environmental impacts?
- If yes, are these likely to be significant or not?
- If yes, are these significant effects likely to occur e.g. is the probability high, moderate or low?

Significance criteria

Criteria to evaluate whether or not adverse impacts are significant include:


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- environmental loss and deterioration;
- social impacts resulting directly or indirectly from environmental change;
- non-conformity with environmental standards, objectives and guidelines; and
- likelihood and acceptability of risk.

Criteria to evaluate adverse impacts on natural resources, ecological functions or designated areas include:


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- reductions in species diversity;
- depletion or fragmentation on plant and animal habitat;
- loss of threatened, rare or endangered species;
- impairment of ecological integrity, resilience or health e.g.
  - disruption of food chains;
  - decline in species population;
  - alterations in predator-prey relationships.

Criteria to evaluate the significance of adverse social impacts that result from biophysical changes include:


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- threats to human health and safety e.g. from release of persistent and/or toxic chemicals;
- decline in commercially valuable or locally important species or resources e.g. fish, forests and farmland;
- loss of areas or environmental components that have cultural, recreational or aesthetic value;
- displacement of people e.g. by dams and reservoirs;
- disruption of communities by influx of a workforce e.g. during project construction; and
- pressures on services, transportation and infrastructure.

Environmental standards, objectives and targets to evaluate significance include:


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- prescribed limits on waste/emission discharges and/or concentrations;
- ambient air and water quality standards established by law or regulations;

- environmental objectives and targets contained in policy and strategy; and
- approved or statutory plans that protect areas or allocate, zone or regulate the use of land and natural resources.

Probability and acceptability of risk

Risk-based principles may be used to establish 'rules of thumb' for the acceptability of effects. For example, a statistical threshold of significance may be established to define an acceptable incidence of disease per million people exposed to a specified hazard (e.g. carcinogenic chemical). This approach is often controversial. It is important to document why and how the level and acceptability of risk has been determined.

A risk-based approach can be useful to address the significance of cumulative effects and ecosystem level changes. Typically, a quantitative risk assessment will not be possible because of lack of knowledge of the variability of natural systems. However, qualitative rules of thumb may be set for cumulative loss or change; for example limiting drainage of wetlands to no more than 25 per cent of the area or some other proportion considered to be significant for maintaining their essential functions of flow regulation, aquatic and bird habitat etc.

Review any guidance available on good practice applying the test of significance to see if it is relevant to local use and application.

The following points summarise international experience on what works well when undertaking evaluation of significance:

- easy-to-use and explain criteria, e.g. health and safety standards;
- criteria that are widely agreed, e.g. threats to rare and endangered species or protected areas; and
- approaches that focus evaluation of significance, including 'references' to cases that are comparable to the proposal.

By contrast, references to biodiversity, sustainability rules and carrying capacity are less easy to justify, more open to argument. However, given their increasing significance, this is an evident area for further work and clarification in guidance on impact evaluation. A list of the types of evaluation criteria that might be used (or adapted) as the starting point for developing sustainability criteria can be found in Boxes 2 and 3.

The approach taken to evaluate significance should reflect the uncertainty and controversy that characterises a specific proposal, for example:

- apply technical criteria when the likely changes associated with a proposal can be predicted with reasonable accuracy e.g. standards,

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environmental quality criteria and risk assessment of certain health impacts; and

- use a negotiation process when factual information is limited and there is a high degree of uncertainty and/or controversy regarding potential impacts (involving experts or affected or interested parties).

In practice, impacts are likely to be significant if they:

- are extensive over space or time;
- are intensive in concentration or in relation to assimilative capacity;
- exceed or approximate to environmental standards or thresholds;
- do not comply with environmental policies, land use plans, sustainability strategy;
- affect ecological sensitive areas and heritage resources; and
- affect community lifestyle, traditional land uses and values.

Briefly discuss the role of mitigation and other steps in the EIA process that relate to the management of significant impacts.

Topic 7 – *Mitigation and impact management* discusses the importance of avoiding, minimising and remedying the potential effects of a proposal.

The test of significance introduced in this topic is applied to residual impacts after mitigation measures have been taken into account. It first requires a technical judgement to be made of the extent to which predicted impacts will be reduced by the action to be taken.

Include a training activity to reinforce the topic (if desired).

Conclude by summarising the presentation, emphasising those key aspects of the topic that apply locally.

Reference list

The following references have been adapted or used as a primary source for major parts of this topic.

Ashe J and Sadler B (1997) Conclusions and Recommendations. *in Report of the EIA Process Strengthening Workshop.* (pp.109-118). Environment Protection Agency, Canberra.

Boyle, J. and Mubvami, T. (1995) *Training Manual for Environmental Impact Assessment in Zimbabwe*. Department of Natural Resources, Ministry of Environment and Tourism. Zimbabwe

Canadian Environmental Assessment Agency (CEAA) (1995) *Guide to the Canadian Environmental Assessment Act.* CEAA, Ottawa.

Canter L (1996) *Environmental Impact Assessment (Second Edition).* McGraw Hill Publishing Company. New York, USA.

Hilden M (1997) Evaluation of the Significance of Environmental Impacts *in Report of the EIA Process Strengthening Workshop* (pp. 49-60). Environment Protection Agency, Canberra.

Leistritz L (1998) Economic and Fiscal Impact Assessment in Porter A and Fittipaldi J (eds) *Environmental Methods Review: Retooling Impact Assessment for the New Century* (pp. 219-227). The Press Club, Fargo, USA.

OECD/DAC Working Party (1994*) Towards Coherence in Environmental Assessment*. 3 Vols. Canadian International Development Agency, Ottawa.

Sadar H and Associates (1995) *Environmental Impact Assessment*. Impact Assessment Centre, Carleton University, Ottawa.

Scott Wilson Ltd. (1996) *Environmental Impact Assessment: Issues, Trends and Practice.* Environment and Economics Unit, UNEP, Nairobi.

Sippe R (1999) Criteria and Standards for Assessing Significant Impact in Petts J (1999) (ed) *Handbook of Environmental Impact Assessment.* Volume 1 (pp.74-92). Blackwell Science Ltd. Oxford, UK.

Taylor N, Goodrich C and Bryan H (1998) Social Assessment in Porter A and Fittipaldi J (eds) (1998) *Environmental Methods Review: Retooling Impact Assessment for the New Century* (pp. 210-218). The Press Club, Fargo, USA.

Wathern P (1988) An Introductory Guide to EIA in Wathern P (ed) *Environmental Impact Assessment: Theory and Practice* (pp.1–28) Routledge, London.

World Bank (1991) *Environmental Assessment Sourcebook.* Volume 1. World Bank Technical Paper No. 139, Washington, D.C.

World Bank (1997) Health Aspects of Environmental Assessment. *Update. Environmental Assessment Sourcebook.* World Bank, Washington, D.C.

World Health Organisation (2001) Guidance to Incorporate Health Considerations into Environmental Impact Assessment. Draft, WHO Europe, Copenhagen.

Further reading

British Medical Association (1998) *Health and Environmental Impact Assessment: An Integrated Approach*. Kogan Page, London, UK.

Petts J (1999) (ed) *Handbook of Environmental Impact Assessment.* Volume 2 Blackwell Science Ltd. Oxford, UK.

Porter A and Fittipaldi J (eds) (1998) *Environmental Methods Review: Retooling Impact Assessment for the New Century.* The Press Club, Fargo, USA.

Vanclay F and Bronstein D (eds) (1995) *Environmental and Social Impact Assessment.* Wiley, Chichester, UK.

Training activities

Training activities will be more instructive if they are framed around a local proposal. Consider inviting prospective course participants to make a presentation if they have expertise in this area of EIA.

Discussion themes

Impact identification

6-1 What are the strengths and weaknesses of the different types of impact identification methods used locally?

6-2 What issues would need to be taken into account if complex or computer-aided EIA methods were used to identify impacts?

6-3 Chemicals used in pesticides accumulate in living tissue and are found in the breast milk of mothers in cities that are a long way from agricultural areas. What methods could be used to identify such indirect impacts?

Impact prediction

6-4 EIA is supposed to predict the impacts of a particular proposal. To what extent does the process involve assumptions and value judgements and how should these be made?

6-5 What are the possible consequences of not carrying out a baseline study?

6-6 Critique the following statements from EIA reports, indicating, as necessary, what additional information is needed to justify or qualify them:

a) The dam will flood the habitat of 40 nesting pairs of raptors. This will be an insignificant impact.

b) The impact on demand for health services by the project workforce (estimated to be 250 for a one-year period) will not be of major significance.

c) An increase in the permanent local population by 200 families due to the fact that the project will not cause a significant impact on infrastructure.

Impact significance

6-7 Discuss the difference between determining significance and decision-making.

6-8 Who should be responsible for determining significance? What principles/criteria can or should be used locally as the basis of determining the significance of different impacts?

6-9 Discuss the following statement: 'The standard says that the allowable discharge limit is 5ml per 100 litres. There's no value judgement in that'.

6-10 What tests/methods could be applied locally to systematically evaluate significance?

Speaker themes

6-1 Invite a speaker who is experienced in managing local EIAs to discuss the various approaches/methodologies that have been used to identify impacts and how they could be improved in future work. The presentation should be supported by examples of the work.

6-2 Invite a speaker who has experience with GIS or predictive models to show the participants how they work and what they can be used for. Ensure that some of the discussion covers the data requirements for the method and that note is made of any limitations.

6-3 Invite a speaker to outline an applicable procedure to determine significance, together with any criteria and methods used that are of relevance to the group of participants.

Group Activity 6–1: Impact Analysis—Impact identification

Title: **Using impact identification methods**

Aim: To gain an understanding of the strengths and weaknesses of the different methods of impact identification that are available.

Group size: Four to six people

Duration: Half to one day, depending on the desired level of detail.

Resources required:

- ❑ Background information from local project(s).
- ❑ Examples of checklists, matrices etc. that can be used or adapted for use for the candidate project(s).
- ❑ List of criteria that could be used to evaluate different impact identification methods, e.g. ease of use, general coverage, ability to identify indirect impacts etc.

Description of activity:

- ❑ Get the group as a whole to adapt/develop the list of criteria to be used to evaluate the impact identification methods.
- ❑ Assign each group the task of using one of the methods (matrix, checklist etc) to identify the impacts for a project.
- ❑ Get each group to evaluate the method using the list of criteria established earlier.
- ❑ Get each small group to present to the group as a whole a summary of the identification method they used, any problems that they encountered, the impacts they identified and how the method rated using the evaluation criteria.

Group Activity 6–2: Impact analysis—Impact identification

Title: **Using a Leopold type matrix**

Aim: To give the participants a 'hands-on' understanding of how to apply a matrix and the results that are obtained.

Group size: Four to six people

Duration: Half to one day, depending on the level of detail.

Resources required:

- Background information from local case study project(s).
- Modified Leopold Matrix (obtain one used locally if possible).
- Copies of handout overpage 'Using a Leopold Matrix'

Description of activity:

- Using the matrix, identify all actions that are part of the project (from the horizontal axis).
- For each action, work down the list of environmental characteristics and place a diagonal line in all of those where an impact is possible.
- For each cell containing a diagonal line rank the magnitude of the impact on a scale from 1 (least) to 10 (most) and place the rank in the top left corner of the cell (a plus (+) may be used for positive impacts and a minus (-) can be used for negative impacts).
- In the lower right hand corner of each cell place a number from 1 (least) to 10 (most) to indicate the importance of the impact (this importance weighting should be determined using an acceptable group process).
- Provide a written report on the most significant impacts to accompany the table.
- As a whole group, review the success of using the matrix.

Using a Leopold-type matrix

Modified Leopold Matrix

Environmental Effects / Development	SOCIAL ENVIRONMENT									
	Recreation	Landscape/visual	Historical/cultural	Personal and social valures	Risks and anxieties	Existing land uses	Land value	Settlement	Employment	Public participation
Treatment										
Comminution										
Sedimentation										
Milliscreening										
Oxidation ponds										
Activated sludge										
Trickling filter										
Nutrient removal										
Chlorination										
Further treatment offsite										
Disposal - Land										
Rapid infiltration										
Surface flooding										
Spray irrigation										
Disposal - Inland Water										
River										
Lake										
Disposal - Marine Water										
Estuary										
Inshore marine										
Offshore marine										
Deep well injection										

The steps in using a Leopold-type matrix are:

- identify all actions that are part of the project (across top of table);
- for each action, work down the list of environmental characteristics and place a diagonal line in all of those where an impact is possible;
- for each cell containing a diagonal line rank the magnitude of the impact on a scale from 1 (least) to 10 (most) and place the rank in the top left corner of the cell (a plus (+) may be used for positive impacts and a minus (-) can be used for negative impacts);
- in the lower right hand corner of each cell place a number from I (least) to 10 (most) to indicate the importance of the impact (this importance weighting should be determined using an acceptable group process); and
- provide a written report on the most significant impacts.

Group Activity 6–3: Impact analysis—Impact identification

Title: **Identifying secondary impacts**

Aim: To raise awareness of the importance of assessing secondary (indirect and cumulative) impacts.

Group size: Four to six people

Duration: Two hours

Resources required:

- ❏ Background information for a local project, particularly the project description and a list of direct impacts.
- ❏ A profile of the environment and community affected, including designated and sensitive areas, and land use.
- ❏ Information on other proposed activities.

Description of activity:

- ❏ Examine the project details and list of direct impacts.
- ❏ Consider what potential is there for regional, national, trans-boundary and global impacts.
- ❏ Consider what potential is there for indirect and cumulative impacts from the project.
- ❏ As a whole group discuss both the implications of not assessing these impacts for this project and possible effects if they are not assessed for a series of similar projects.

Group Activity 6–4: Impact analysis—Baseline data

Title: **Planning for baseline data collection**

Aim: To provide an appreciation of the role and importance of collecting baseline data.

Group size: Four to six people

Duration: Half to one day, depending on the level of detail required by participants.

Resources required:

- Background information for a local project that includes a plan (or can be used to develop one) for baseline data collection.
- Checklist or matrix appropriate for use to identify the impacts of the project.

Description of activity:

- Given the project description, use the checklist or matrix to identify the major impacts that require further analysis.
- For each impact, list the types of baseline data that could be required and identify any sources that may already exist for obtaining the information.
- Compare the strengths and weaknesses of the list that the groups have developed with that developed for the actual project (where available).

Group Activity 6–5: Impact analysis—Significance

Title: **Review of determination of significance.**

Aim: To gain familiarity with procedure and criteria for evaluating and determining impact significance.

Group size: Pairs

Duration: Half-day

Resources required:

- ❑ An EIA report for each pair

Description of activity:

Each pair is to:

- ❑ review the EIA report, listing the major impacts that were analysed;
- ❑ for each major impact, identify the significance procedure and/or criteria by which the impact was evaluated; and
- ❑ summarise the strengths and weaknesses of the approach and the way the findings were reported.

The whole group should convene to discuss the findings.


1

The 'impact analysis' or detailed study phase of EIA involves:

- identifying the impacts more specifically
- predicting the characteristics of the main impacts
- evaluating the significance of the residual impact


2

The term 'environment' includes:

- human health and safety
- flora, fauna, ecosystems and biodiversity
- soil, water, air, climate and landscape
- use of land, natural resources and raw materials
- protected areas and sites of special significance
- heritage, recreation and amenity assets
- livelihood, lifestyle and well being of affected communities


3

Impact identification methods:

- checklists
- matrices
- networks
- overlays and geographic information systems (GIS)
- expert systems
- professional judgement


4

Example of a checklist

Aspects of EIA	Check list Questions Will the project:	Yes	No	Additional Data needs
Sources of Impacts	1. Require the acquisition or conversion of significant areas of land for reservoir/treatment works etc. (eg. >50 ha rural, >5ha urban)?	☐	☐	☐
	2. Result in significant quantities of eroded material, effluent or solid wastes?	☐	☐	☐
	3. Require significant accommodation or service amenities to support the workforce during construction (eg >100 manual workers)?	☐	☐	☐
Receptors of Impacts	4. Flood or otherwise affect areas which support conservation worthy terrestrial or aquatic ecosystems, flora or fauna (eg protected areas, wilderness areas, forest reserves, critical habitats, endangered species); or that contain sites of historical or cultural importance?	☐	☐	☐
	5. Flood or otherwise affect areas which will affect the livelihoods of local people (eg require population resettlement; affect local industry, agriculture, livestock or fish stocks; reduce the availability of natural resource goods and services)?	☐	☐	☐
	6. Involve siting sanitation treatment facilities close to human settlements (particularly where locations are susceptible to flooding)?	☐	☐	☐
	7. Affect sources of water extraction?	☐	☐	☐
Environmental Impacts	8. Cause a noticeable permanent or seasonal reduction in the volume of ground or surface water supply?	☐	☐	☐
	9. Present a significant pollution risk through liquid or solid wastes to humans, sources of water extraction, conservation worthy aquatic ecosystems and species, or commercial fish stocks?	☐	☐	☐
	10. Change the local hydrology of surface water-bodies (eg streams, rivers, lakes) such that conservation-worthy or commercially significant fish stocks are affected?	☐	☐	☐
	11. Increase the risk of diseases in areas of high population density (eg onchocerciasis, filariasis, malaria, hepatitis, gastrointestinal diseases)?	☐	☐	☐
	12. Induce secondary development, eg along access roads, or in the form of entrepreneurial services for construction and operational activities?	☐	☐	☐
Mitigation Measures	13. Be likely to require mitigation measures that may result in the project being financially or socially unacceptable?	☐	☐	☐
Comments				
	I recommend that the programme be assigned to Category	☐		
	Signature Delegation ………………………………Desk………………………………			

Topic 6

Impact analysis

5

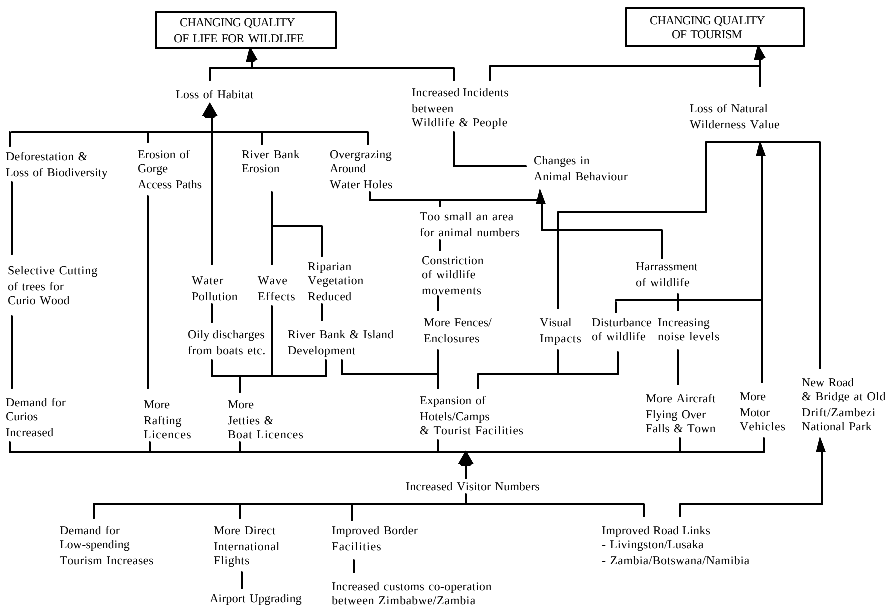
Example of Leopold type matrix

Modified Leopold Matrix

Development \ Environmental Effects (SOCIAL ENVIRONMENT)	Recreation	Landscape/visual	Historical/cultural	Personal and social valures	Risks and anxieties	Existing land uses	Land value	Settlement	Employment	Public participation
Treatment										
Comminution										
Sedimentation										
Milliscreening										
Oxidation ponds										
Activated sludge										
Trickling filter										
Nutrient removal										
Chlorination										
Further treatment offsite										
Disposal - Land										
Rapid infiltration										
Surface flooding										
Spray irrigation										
Disposal - Inland Water										
River										
Lake										
Disposal - Marine Water										
Estuary										
Inshore marine										
Offshore marine										
Deep well injection										

6

A network



Network Showing Impact Linkages Leading to Changes in Quality of Life, Wildlife and Tourism (arising from increased visitor numbers) (Bisset)

7 **Choice of EIA method depends on:**

- the type and size of the proposal
- the type of alternatives being considered
- the nature of the likely impacts
- the availability of impact identification methods
- the experience of the EIA team with their use
- the resources available - cost, information, time, personnel

8 **Main advantages and disadvantages of impact identification methods**

	ADVANTAGES	DISADVANTAGES
Checklists	• simple to understand and use • good for site selection and priority setting • simple ranking and weighting	• do not distinguish between direct and indirect impacts • do not link action and impact • the process of incorporating values can be controversial
Matrices	• link action to impact • good method for displaying EIA results	• difficult to distinguish direct and indirect impacts • significant potential for double-counting of impacts
Networks	• link action to impact • useful in simplified form for checking for second order impacts • handles direct and indirect impacts	• can become very complex if used beyond simplified version
Overlays	• easy to understand • good display method • good siting tool	• address only direct impacts • do not address impact duration or probability
GIS and computer expert systems	• excellent for impact identification and analysis • good for 'experimenting'	• heavy reliance on knowledge and data • often complex and expensive

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Information required about the environment to establish baseline conditions:

- current conditions
- current and expected trends
- effects of proposals already being implemented
- effects of other proposals yet to be implemented

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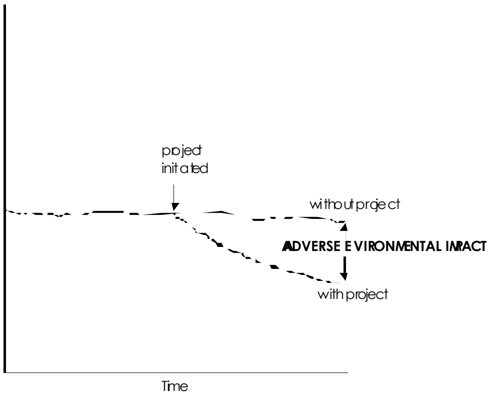
An environmental impact



(Wathern, 1988)

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Impact characteristics can vary in:

- nature (positive/negative, direct/indirect)
- magnitude (severe, moderate, low)
- extent/location (area/volume covered, distribution)
- timing (during construction, operation etc, immediate, delayed)
- duration (short term/long term, intermittent/continuous)
- reversibility/irreversibility
- likelihood (probability, uncertainty)
- significance (local, regional, global)

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Impact characteristic summary table

IMPACT CHARACTERISTIC	IMPACT TYPE		
	air quality	health	etc
nature			
magnitude			
extent/location			
timing			
duration			
reversibility			
likelihood (risk)			
significance			

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Methods of impact prediction:

- 'best estimate' professional judgement
- quantitative mathematical models
- experiments and physical models
- case studies as analogues or references

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Types of uncertainty in impact prediction

- scientific uncertainty
  – limited understanding of the ecosystem or community affected
- data uncertainty
  – incomplete information or insufficient methodology
- policy uncertainty
  – unclear or disputed objectives or standards

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Types of social impact

- demographic
  – changes to population numbers, distribution
- cultural
  – changes to customs, traditions and values
- community
  – changes to cohesion, relationships etc.
- socio-psychological
  – changes to quality of life and well being


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Examples of health impacts by sector

	Communicable disease	Non communicable disease	Nutrition	Injury	Psychosocial disorder and loss of well-being
Mining	Tuberculosis	Dust induced lung disease		Crushing	Labour migration
Agriculture	Parasitic infections	Pesticide poisoning	Loss of subsistence		
Industry		Poisoning by pollutants		Occupational injury	Disempower-ment
Forestry			Loss of food production	Occupational injury	
Dams and irrigation schemes	Water borne diseases	Poisoning by pollutants	Increased food production	Drowning	Involuntary displacement
Transportation	HIV/Aids	Heart disease		Traffic injury	Noise and induced stress
Energy		Indoor air pollution		Electromagnetic radiation	Community displacement


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Factors affecting economic impacts

- duration of construction and operation
- workforce requirements for each period
- skill requirements (local availability)
- earnings
- raw material and other input purchases
- capital investment
- outputs
- the characteristics of the local economy


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Factors affecting fiscal impacts

- size of investment and workforce requirements
- capacity of existing service delivery and infrastructure systems
- local/regional tax or other revenue raising processes
- demographic changes arising from project requirements

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Box 3: Examples of threshold tests for environmental acceptability	
Level of acceptability	Potential impact threshold
Unacceptable	Exceeds legal threshold, e.g. quality standard
Unacceptable	Increases level of risk to public health and safety above qualitative or quantitative criteria (e.g. in some jurisdictions an increased risk of death of 1 in a million per year
Unacceptable	Extinction of biological species, loss of genetic diversity, rare or endangered species, critical habitat
Normally unacceptable	Conflict with existing environmental policies, land-use plans
Normally unacceptable	Loss of populations of commercial biological species
Normally unacceptable	Large-scale loss of productive capacity of renewable resources
May be acceptable only with minimization, mitigation, management	Avoidance of spread of biological disease, pests, feral animals, weeds
May be acceptable only with minimization, mitigation, management	Taking of rare or endangered species
May be acceptable only with minimization, mitigation, management	Some loss of threatened habitat
Normally acceptable	Some loss of populations and habitats of non-threatened species
Normally acceptable	Modification of landscape without downgrading special aesthetic values
Normally acceptable	Emissions demonstrably less than the carrying capacity of the receiving environment
Source: Sippe 1999	

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Key elements for assessing impact significance:

- environmental standards
- level of public concern
- scientific and professional evidence concerning:
- resource loss/ecological damage
- negative social impacts
- foreclosure of land and resource use options

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Guiding principles for determining impact significance:

- use established procedure or guidance
- adapt relevant criteria or comparable cases
- assign significance rationally and defensibly
- be consist in the comparison of alternatives
- document the reasons for judgements

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Test for significance by asking three questions:

- are there residual environmental impacts?
- if yes, are these likely to be significant or not?
- if yes, are these significant effects likely to occur?

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Impact significance criteria

- environmental loss and deterioration
- social impacts resulting from environmental change
- non-conformity with environmental standards
- probability and acceptability of risk

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Ecological significance criteria

- reduction in species diversity
- habitat depletion or fragmentation
- threatened, rare and endangered species
- impairment of ecological functions e.g.

– disruption of food chains;

– decline in species population;

– alterations in predator-prey relationships.

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Social significance criteria

- human health and safety
- decline in important resource
- loss of valued area
- displacement of people
- disruption of communities
- demands on services and infrastructure

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Environmental standards:

- limits on waste/emissions discharge and concentrations
- clean air standards, water quality standards
- policy objectives and targets
- plans that allocate use of land and natural resources

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Alternative approaches to determine significance:

- apply technical criteria when changes are predictable
- use negotiation when significance is disputable

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Impacts are likely to be significant if they:

- are extensive over space or time
- are intensive in concentration or in relation to assimilative capacity
- exceed environmental standards or thresholds
- do not comply with environmental policies/ land use plans
- affect ecological sensitive areas and heritage resources
- affect community lifestyle, traditional land uses and values