Environmental Impact Assessment

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Advanced article

Article Contents

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Environmental impact assessment (EIA) is a systematic process designed to identify and predict the potential impacts of human activity on the biophysical and human environment. It also functions as an environmental management tool to identify measures to avoid, mitigate or compensate for those effects. EIA is intended to be an iterative process to follow-up to projects post-implementation to determine actual environmental outcomes, interpret and communicate information about those outcomes and investigate opportunities for improved project environmental performance. Originating from the United States' National Environmental Policy Act of 1970, EIA is now amongst the most successful and widely practiced environmental management tools in the world.

Introduction

There is no single, universally accepted definition of environmental impact assessment (EIA). The term EIA is often used interchangeably with 'Environmental Assessment' or 'Impact Assessment'. The International Association for Impact Assessment (IAIA), the leading global authority on best practices in EIA, and the UK Institute of Environmental Assessment (IEA) define EIA as:

The process of identifying, predicting, evaluating, and mitigating the biophysical, social, and other relevant effects of development proposals prior to major decisions being taken and commitments made (IAIA and IEA, 1999).

EIA is a means to aid decision making through which concerns about the potential environmental consequences of proposed actions, public or private, are incorporated into decisions regarding those actions (Noble, 2010). This 'look before you leap' approach is the basic concept behind EIA. In simplest terms, EIA is an integral component of sound decision making, serving both an information-gathering and an analytical component, used to inform decision-makers concerning the impacts and management of proposed developments. Defined by the UNEP (1987), EIA is 'an examination, analysis and assessment of planned activities with a view to ensuring environmentally sound and sustainable development'. **See also**: Conservation Biology and Biodiversity; Sustainable use of Populations and Overexploitation

EIA necessarily has a substantial scientific component. It is an organised means of gathering information used to identify and understand the potential impacts of proposed projects on the biophysical environment (e.g. air, water, land, plants and animals) as well as on the human environment (e.g. culture, health, community sustainability, employment and economy). However, EIA also interprets and communicates information about those impacts. Because potential impacts are interpreted, EIA is very much based on human values and professional judgment. EIA is also a management tool because it involves proposing means for managing the impacts of a proposed project that might occur following the consent decision for development (Morrison-Saunders and Bailey, 1999).

According to the World Bank, EIA is the most widely practiced environmental management tool in the world. Sadler has described EIA as 'one of the more successful policy innovations of the twentieth century', noting that it is 'used in more than 100 countries and organisations to help decision makers consider the environmental consequences of proposed actions' (Sadler, 1996, p. 1).

Purpose and Objectives of EIA

The underlying intent of EIA is to allow project proponents, managers and decision makers to enhance the benefits and to minimise the environmental costs of development projects. When it is discovered that the potential effects of a proposed project are likely to be so adverse as to make the costs greater than the benefits, it can be rejected before, rather than after the project is

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constructed. In this sense, EIA is a planning and management tool for choosing and designing developments wisely. Its primary purpose is to facilitate the consideration of environment in planning and decision making and, ultimately, to make it possible to arrive at decisions and subsequent actions that are more environmentally sustainable.

EIA is also often viewed in a much broader context – as a means to influence government decisions and to provide an opportunity for public debate about the merits of a proposed development. Cashmore (2004) characterises EIA as operating along a broad spectrum of philosophies and values. At one end of this spectrum is the view that the scientific method provides the basis for EIA theory and practice and that in order to be credible the EIA process must be based on scientific objectives, modelling and experimentation, quantified impact predictions and hypotheses testing. At the other end of the spectrum is the view that EIA is a tool to empower local stakeholders and promote social justice and community self-governance.

In practice, EIA typically operates somewhere in between as an information provision and decision support process for the purposes of ensuring that environmental factors are explicitly addressed in decision-making processes concerning proposed developments; improving the design of proposed developments; anticipating, avoiding, minimising and offsetting adverse effects; and facilitating informed decisions about development. In doing so, EIA can help realise several broader and longer-term outcomes including protecting the productivity and capacity of natural and human systems; providing a means for public debate about the nature and direction of development; facilitating learning and environmental education; facilitating participatory approaches to development and decision making; and promoting development that is sustainable.

Origins and Evolution of EIA

In the 1960s it became apparent that large industrial developments were having major adverse environmental impacts. Because of increasing environmental awareness due to Carson's *Silent Spring* (1962), the work of others such as Barry Commoner and Garret Hardin, and events such as Earth Day on 22 April 1970, attention became focused on what could be done to avoid the most obvious damage. A significant outcome was the United States' National Environmental Policy Act (NEPA), introduced in 1969 and becoming law in 1970, which set the first, legal foundation for EIA. Since NEPA, EIA has gone through a number of evolutionary phases in North America, a pattern repeated to varying degrees throughout the world (Wood, 1995). **See also**: Carson, Rachel Louise

During the early years of EIA, throughout the 1970s, the life sciences were the focus of many EIAs, because the most obvious impacts were changes in habitats and in fish and wildlife populations. EIAs were characterised by extensive inventories of the biophysical environment, requiring considerable time and resource investments. However, as baseline data became established, and with the introduction of scoping procedures in EIA, further environmental inventories became less essential because existing databases could be used and EIAs became more focused and sensitive to decision timelines. The focus shifted to the quality of the impact predictions, secondary and tertiary impacts and socioeconomic impacts. **See also**: Conservation of Biodiversity

Throughout the 1980s and into the early 1990s EIA experienced considerable international growth, due in part to a number of international events such as the 1987 World Commission on Environment and Development and the 1992 and 1997 Earth Summits, all of which fostered greater international awareness of EIA. During this period, EIA had begun to emerge as an integrated planning tool for decision making characterised by increasing awareness of the relationships between society and the biophysical environment. In more recent years, increasing emphasis has been placed on cumulative environmental effects and advancing EIA as a precautionary and adaptive approach to environmental management. In some jurisdictions, such as Canada, EIA is recognised as a tool to support decisions about development that are consistent with the principles of sustainable development.

Today, EIA is recognised as one of the more consistent and unquestionably powerful instruments for environmental management (Hanna, 2005). Introduced initially with a project-specific focus, EIA has triggered the development of many other forms of assessment and appraisal. These include social impact assessment, health impact assessment, ecological risk assessment and strategic environmental assessment for policies, plans and programmes.

The EIA Process

EIA is often linked to the rationalist approach to planning and decision making, requiring a technical evaluation as the basis for objective decisions (Owens *et al*., 2004). Core to this approach is the assumption of a well-defined problem characterised by a range of options, complete information and objective decision makers. Although information in EIA is rarely value-free or complete, and is frequently constrained or shaped by political factors and societal interests, the rationalist approach remains a valid representation the framework within which EIA is often used as a tool for planning and decision making (Hanna, 2005).

The basic steps in undertaking an EIA include: (1) screening; (2) scoping; (3) impact prediction and evaluation; (4) mitigation; and (5) follow-up studies undertaken for those projects that proceed to implementation (see **Figure 1**). Information gained in the follow-up studies provides feedback to improve predictions and mitigation and management programmes, and opportunity to learn for subsequent project proposals and EIAs.

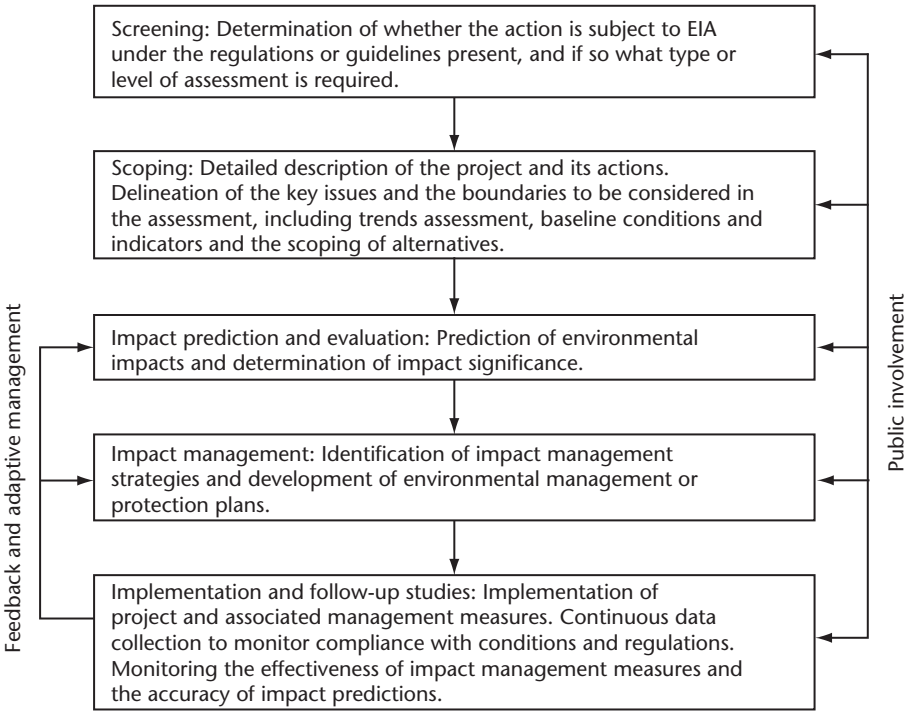

Figure 1 Generic environmental impact assessment process.

Screening

Not all development proposals require EIA. Screening ensures that unnecessary assessments are not carried out but that developments warranting assessment are not overlooked. Screening simply refers to the narrowing of the application of EIA to those projects that require assessment because of perceived significant environmental effects or specific regulations. Projects with trivial impacts must be excluded, wheras major projects likely to have significant impacts must be examined in detail. Projects with modest impacts should be subject to a focused EIA directed at issues of concern to decision makers. In some jurisdictions, these focused EIAs are often called 'screening assessments' and are applied to routine project proposals, such as minor road extensions or river crossings, for which less rigorous assessment is required and significant impacts are unlikely should known mitigation practices be followed.

Screening as the trigger for EIA asks: Is an EIA required and, if so, to what extent? Screening will result in one of the following decisions: (1) no EIA is required; (2) EIA is required; (3) a limited EIA is required, consisting of a preliminary assessment or mitigation plan; or (4) further study is necessary, an initial environmental evaluation, to determine whether an EIA is required (Noble, 2010). Screening is the responsibility of the institution responsible for the EIA process. It is usually carried out by one or more of inclusion lists (lists of projects for which EIA is automatically required), exclusion lists (lists of projects automatically exempt from EIA requirements) or ad hoc (case by case) examinations of projects to see what their impacts are likely to be. Unfortunately, for economic, political and historical reasons, agriculture, fisheries, forestry and urbanisation projects are too often not required to do EIA, even though they can have major environmental and socioeconomic impacts (Duffy, 2004). **See also**: Agricultural Production; Agricultural Systems: Ecology; Forestry Management and Production

The precautionary principle necessarily plays an important role in screening. The precautionary principle suggests that when scientific information is incomplete, but there is threat of adverse impacts, the lack of full certainty should not be used as a reason to preclude or to postpone actions to prevent harm. When there is uncertainty as to whether a proposed development is likely to cause adverse environmental effects, the lack of certainty should not be a reason for not requiring an EIA, or for not requiring mitigation and monitoring actions (IAIA, 2003).

Scoping

For those projects requiring EIA, it is essential to focus the EIA on those impacts that will make a difference to decisions about the proposed project. Scoping determines the important issues and parameters that should be addressed in EIA, establishes the spatial and temporal boundaries of the assessment and focuses the assessment on the relevant issues and concerns. Scoping is undertaken through consultations with scientific and technical specialists, with members of the affected public, with the project proponent and with interest groups. It identifies those components of the biophysical and human environment that may be

affected by development and for which there is scientific, regulatory or public concern. These components are often called valued ecosystem components. In essence, scoping is about limiting the amount of information to be gathered for an EIA to a manageable level and identifying specific objectives and indicators to guide the assessment. This involves determining what elements of the project to assess, what environmental components are likely to be affected, how these environmental components have changed over time, what factors have driven such change and how these components may be affected by other actions or disturbances in the project environment.

A large volume of topics could be included in an EIA and a long list of techniques for collecting that data could be employed, including census data, historic records, land-use plans, field surveys and sampling procedures. The final determination of what must be addressed in the EIA must be that of the responsible administering authority. On the basis of the scoping exercise, the responsible authority issues terms of reference for the EIA that state what issues will be studied.

Though what is studied varies greatly from project to project, typical biophysical components often include species of concern, including endangered or threatened species and species used by local populations for hunting and gathering, surface and ground water quality and quality, habitat conditions, components of the atmospheric environment and various physical geography parameters including vegetation, landforms, soil and geological properties. Public perception and values often has significant influence on what components of the biophysical and human environment receive attention in EIA. For example, charismatic species such as grizzly bears, elk, bighorn sheep, whales and dolphins or commercially valuable species, are often perceived by the public to be much more important than amphibians or rodents, though the latter may be important ecological indicators and still warrant consideration in EIA for scientific reasons. For the human environment, baseline conditions, patterns and trends are often established for such parameters as community health, employment, social infrastructure, Aboriginal lands and cultural practices. **See also**: Biodiversity – Threats

Impact prediction and evaluation

What project impacts are predicted in EIA is very much determined by the scoping results. However, cause–effect relationships are not always known and many components of the natural and human environment are moving targets. As a result, predicting the potential impacts of a project is a complex task. Morris and Therivel (2001) suggest that impact prediction requires, at a minimum: (1) a sound understanding of the nature of the proposed undertaking; (2) knowledge of the outcomes of similar projects; (3) knowledge of past, present or approved projects whose impacts may interact with the proposed undertaking; and (4) information about environmental and socio-economic receptors and how they might respond to change. This information is normally achieved through scoping and baseline studies.

When predicting the impacts of a proposed development on those components of the natural and human environment identified during the scoping process, there are several impact characteristics that should be identified and documented including: (1) the nature of the predicted impact (e.g. whether it is positive, adverse, additive and antagonistic); (2) the temporal duration of the impact; (3) magnitude, direction and spatial extent; (4) degree of reversibility; and (5) the likelihood that the predicted impact will actually occur.

Methods for predicting impacts are varied, reflecting both the wide variety of issues often dealt with in EIA and the variety of tasks needed to ensure credible EIA. Tools used for impact prediction cover a wide spectrum of economic, social, ecological and physical factors, and generally include models, extrapolation, experimental design, experience from similar projects elsewhere, expert judgement, scenario-based analysis and spatial analytical tools including Geographic Information Systems (Glasson *et al*., 1999; Harrop and Nixon, 1999). **See also**: Ecological Modelling

Having predicted the impacts, the significance of those impacts must be determined. Determination of impact significance essentially involves making judgments about the importance of environmental effects (Lawrence, 2007). Significance reflects the degree of importance placed on the effects in question and involves consideration of both the nature of the environmental effect itself and the importance or sensitivity of the affected environmental component (Noble, 2010). Only by determining the significance of impacts can one influence project decisions meaningfully. In particular, the choice of what impacts require mitigation to make the project acceptable can only be established through a determination of significance. Insignificant impacts should not generally require mitigation, but significant adverse impacts should be mitigated.

The significance of an impact is often determined by considering such factors as:

- the intensity or concentration of the impact;
- the frequency or duration of the impact;
- whether the impact is likely to occur at a broad spatial scale;
- irreversibility of the impact;
- the potential for cumulative environmental effects;
- whether the impact will affect the resiliency of a socio-economic system;
- whether ecological functions will be affected or assimilative capacities exceeded;
- compliance with standards or regulations;
- societal importance and public concern about the affected component;
- sensitivity, vulnerability or irreplaceability of the affected component; and
- whether the impact can be appropriately mitigated or managed.

Impact management

Impact management is core to the EIA process. For those impacts that are deemed significant and adverse, it is important that they be managed to the point of public acceptability. This is most commonly done through changes to the project so that the impacts do not occur, are reduced in severity, or are otherwise mitigated to become less significant. Project redesign or adjustments to project operation are the usual tools of mitigation. Compensation can also be used to overcome or offset impacts. Compensation can be 'in kind', such as creation of new wetland habitat to replace wetland habitat lost due to the project, or financial or equivalent to those people who lose valued resources or who will experience adverse impacts as a result of the project, for example, building enhanced artificial breeding or spawning habitats. From a sustainability perspective, impact management can also take the form of creating or enhancing positive impacts, for example, employment creation, commitment to a greater percentage of local hiring or 'buy local' policies for construction materials to enhance the financial wellbeing of local businesses. The determination of potential impacts is often imprecise because of uncertainties surrounding such factors as the project's design and timetable or because of exogenous factors. Thus, impact management practices must be flexible enough to respond to unanticipated impacts as well as differences between the actual and predicted nature, level or significance of the impacts. **See also**: Bioremediation; Plant Reproduction; Restoring Rivers and Streams; Wetlands

Follow-up studies

For those projects that proceed to implementation following an EIA review, it is essential to ensure that predictions were accurate, that there were no unanticipated impacts, and that the environmental management and mitigation plans developed for the project were implemented and were effective. Follow-up studies transform EIA from a static assessment process to a dynamic environmental management process (Arts *et al*., 2001). In the absence of follow-up, the EIA exercise is little more than an expensive permit-granting exercise. Follow-up guidance published by the IAIA identifies four main components to follow-up studies:

- Monitoring – data collection before project implementation (baseline monitoring) and after project implementation (compliance and impact monitoring).
- Evaluation – determining conformance with standards, predictions or expectations as well as the environmental performance of the project itself.
- Management – making decisions and taking appropriate action in response to unanticipated impacts or other issues arising from monitoring and evaluation activities.
- Communication – informing stakeholders about the results of follow-up studies in order to provide feedback on project implementation, impact management strategies, as well as feedback on EIA processes.

Public involvement

Engagement of the public is required in some form in most EIA systems around the world. There are also international provisions with respect to public involvement in EIA, including the 1991 Espoo Convention on Environmental Impact Assessment in a Transboundary Context and the 1998 Aarhus Convention on Access to Information, Public Participation in Decision Making and Access to Justice in Environmental Matters. Public involvement broadly refers to the involvement of individuals and groups that are positively or negatively affected by a proposed intervention subject to a decision-making process or are interested in it (André *et al*., 2006).

Public involvement should occur at all stages of the EIA process. Though public involvement may extend the time needed during the initial project planning and scoping phases, this initial investment is usually returned later in the process because it minimises or avoids potential conflicts (Noble, 2004). By involving the public in EIA it is possible to, among other things: (1) access a wide range of information, including traditional knowledge; (2) identify socially acceptable solutions; (3) ensure more balanced decision making; (4) minimise conflict and potential costly delays; (5) reduce the possibility of legal challenge; and (5) promote social learning.

Levels of public participation in EIA vary from passive participation or information reception (such as media releases or information bulletins), to participation through consultation (such as public hearings and open-houses), to interactive participation (such as workshops, negotiation or comanagement) (André *et al*., 2006). Different levels of public involvement may also be used throughout the EIA process, and different members of the public may need to be involved in different capacities at each stage of the EIA process from initial project notice and scoping to project approval and post-approval follow-up studies.

Professional Practice of EIA

There are many professional roles for EIA practitioners: field work to complete the inventory, predicting, modelling and determining significance of impacts, designing and implementing mitigation and management measures, EIA administration, reviewing EIA documents, reviewing projects subject to EIA, project decision making and the preparation of EIAs. Consultants, and typically interdisciplinary teams of consultants, usually carry out the preparation of EIAs on behalf of project proponents. The interdisciplinary nature of the teams that carry out EIAs is of critical importance. The team must have access to the complete set of expertise necessary to carry out baseline

studies, make predictions of impacts and assess them, propose mitigation and management measures, design follow-up procedures and involve the public. If important skills are lacking, critical impacts or possible mitigation measures can be missed, and conflict may arise amongst the affected public. To be successful, team leaders and team members will need teamwork skills, interdisciplinary skills and communications skills.

There is no internationally recognised certification for EIA professionals, though some jurisdictions do have certification requirements for EIA practitioners (e.g. South Africa), whereas many others recognise certain professional designations (e.g. professional biologist, geographer, engineer or geoscientist) but have no EIA certification requirements per se. There are, however, minimum international guidelines for EIA professionals. In 2006, the IAIA adopted 'Guidelines for Lead IA Practitioners'. The guidelines establish the minimum standards for the profession and differentiate between 'lead practitioner' and 'lead administrator'. For lead practitioner, included amongst the standards are that the practitioner hold a relevant university degree (such as in environmental studies, geography, ecology, biology, sociology, social anthropology, planning, engineering and landscape architecture), have at least 10 years of progressively senior experience in designing, undertaking and reporting on EIAs, have a thorough understanding of EIA methods, and a demonstrated ability to think holistically about the structure, functioning and performance of ecological, socio-economic and political systems. For lead administrator the standards are similar, but as opposed to knowledge of EIA methods there is a required knowledge of the relevant environmental and related institutions, legislation, policies and administrative procedures.

EIA in Developing Countries

EIA in developing countries is practiced primarily for two reasons. The first is to comply with EIA provisions in the country; the second is to meet the EIA requirements of development aid agencies. EIA was introduced early in some developing countries, including Columbia (1974) and the Philippines (1977). It was not until well into the 1980s (e.g. Brazil, Indonesia, Mexico, Algeria and Turkey), however, and particularly so in the 1990s (e.g. Belize, Boliva, Gambia, Mongolia and Tunisa) that many developing countries established formal legislative bases for EIA or introduced EIA provisions into their existing environmental legislative frameworks.

The World Bank first introduced EIA requirements in 1989 for evaluating projects it was financing; the Asian Development Bank followed in 1993 with similar requirements (Harrop and Nixon, 1999). The Canadian International Development Agency also has EIA requirements for international investment and development projects and recently adopted a system of environmental assessment to address the potential environmental impacts associated with policy and programme decisions. One widely known review is the Three Gorges Dam on China's Yangtze River (Morrow and Morrow, 1997), commissioned by the World Bank and the Canadian International Development Agency (CIPM Yangtze Joint Venture, 1988). The Three Gorges Dam project proceeded in spite of knowledge of very large social and environmental impacts. **See also**: Restoring Rivers and Streams

EIA legislation in many developing countries is of high quality, much like legislation in developed countries. The main differences lie in implementation. It is widely recognised that EIA capacity in developing countries needs strengthening, especially within government agencies. However, EIA education and training opportunities at post-secondary institutions in developing countries is still relatively limited in comparison to opportunities at institutions in developed nations, particularly the United Kingdom, United States and Canada. Further, government policy is for economic development first and environmental protection later, failing to recognise the costs of such policies; project proponents rely on economic and engineering feasibility, and do not necessarily attempt to incorporate environmental liabilities until late in the project.

Efficacy of EIA

Since it was first introduced in the early 1970s, EIA has long been recognised as one of the most important regulatory tools for environmental protection (Hickey *et al*., 2010). Stemming from reactive regulatory controls for environmental pollution, EIA has become a proactive tool for impact identification and mitigation of potentially adverse environmental effects. In recent years EIA has been applauded for being a more integrative (Gibson, 2002), more participative (Diduck and Sinclair, 2002), more comprehensive (Gibson, 2002) and more closely monitored environmental planning and management tool.

There are numerous success stories of EIA in improving project design and minimising and avoiding potentially adverse impacts. In one project, for example, a proposal for a bleached kraft pulp mill was reviewed on the Athabasca river system in western Canada. The proposed project would have been the cleanest bleached kraft pulp mill in the world at the time, based on the lowest emission of chlorinated organic compounds per unit of pulp produced. However, the EIA process identified residual environmental concerns with the emissions on the river system, namely bioconcentration, bioaccumulation and biomagnification of dioxins and furans in fish that could exceed concentrations acceptable to Health Canada for commercial sale of the fish, which led to a revised technology being proposed. The new technology reduced the chlorinated emissions by a further factor of 5, to 20% of the originally proposed values, and thus to a much more acceptable impact on the environment (Alberta-Pacific EIA Review Board, 1990). **See also**: Ecophysiological Responses of Plants to Air Pollution

A second example is the Hibernia offshore oil field, discovered on the Grand Banks of Canada's eastern continental shelf in 1979. Approval was granted for its development in 1986, with construction starting in 1990. A multiyear programme was established to monitor the effects of the construction of the offshore production platform at the near-shore construction site – an area rich in marine invertebrates, fish and marine mammals. The objectives of the monitoring programme included an assessment of the effectiveness of environmental protection and mitigation measures, providing early warning of undesirable change and assurance that impacts predicted in the EIA to be insignificant were in fact insignificant. For each measured variable a null hypothesis was developed stating that activities associated with site development and construction will not elevate the concentration or degree of the variable to a level which exceeds the maximum allowable effects level for that variable. Maximum allowable effects levels were based on national and international regulations, standards and guidelines for marine environmental components. Monitoring data were analysed by independent commercial and university laboratories. Findings from the analyses were that none of the null hypotheses could be rejected. In other words, mitigation measures implemented through the EIA resulted in the construction project having no adverse impacts on the marine environment beyond acceptable levels. A similar approach was adopted for the EIA monitoring programme for the offshore development phase of the Hibernia project, and subsequent offshore developments in the area – Terra Nova in 2002 and White Rose in 2005 (Storey and Noble, 2004). **See also**: Marine Communities

In a final example, in 1997 Voisey's Bay Nickel Company Limited submitted a proposal to develop a rich nickel–copper–cobalt deposit in eastern Canada. The public review panel commissioned for the EIA issued guidelines for the review in which the proponent was required to discuss explicitly the extent to which the project would make a positive overall contribution towards the attainment of ecological and community sustainability. This was the first major resource development project in Canada for which the impact statement guidelines for the project proponent explicitly identified the sustainability criterion; requiring a project proponent to go beyond minimising harm and ensuring maximise long-term, durable net gains. Construction of the project commenced in 2002.

It would be less than fair, however, to suggest EIA is an unqualified success. EIA can be quite ineffective if not used properly: (1) if proponents undertake EIA after the project is designed; (2) if scoping misses significant components and/or predictions of impacts are not accurate; (3) if decision makers fail to use EIA results in making development decisions; or (4) if the implementation of projects subject to EIA fails to follow through effectively with the sound environmental management plans developed through the EIA process. All of these problems have been experienced with EIA, and the efficacy of EIA has, on many occasions, been called into question. Of particular concern to the efficacy of EIA is the increasing streamlining of EIA processes and the lack of EIA application to small, seemingly insignificant and routine development actions (Seitz *et al*., 2011). The efficacy of EIA has been increasingly under the spotlight as many nations seek to increase their global economic competitiveness and streamline and simplify environmental regulation as a means to attract investment (Cashmore *et al*., 2010). This quest for increased efficiency in EIA, by either avoiding applications for small projects or deregulating to promote increased development investment, may be at the cost of sound environmental decision making in the long term.

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