Environmental Methods Review: Retooling Impact Assessment for the New Century

AEPI

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Introduction

Alan L. Porter and John J. Fittipaldi

Methods

This volume is about "methods"—the tools and techniques of environmental assessment (EA) and impact assessment (IA). It seeks to set forth "what's new and important" in methods to conduct particular facets of EA/IA. The stance is that of an annual review—pointing the reader to the frontiers of the state of the art of good practice, with a review of recent contributions to the literature and to case applications of note.

The title reflects an amalgamation of methods pertinent to environmental issues. "Retooling for the new century" suggests that new emphases warrant improved methods. In particular, efforts to accomplish sustainable development demand enriched IA integrated with environmental management systems. This volume keys on the IA methods. Specific interest in furthering methodological development traces back to shared concerns of John Bailey and Alan Porter from 1994—namely, that attention and resources need to be invested in improving the tools of EA/IA.

The primary aims of this volume are to:

- Provide guidance to practitioners within the Army and other member services, military contractors, and others concerned with environmental impact assessment (EIA) and other forms of impact assessment
- Offer current thinking on how to address important methodological issues
- Highlight recent developments in concepts and applications
- Identify key resources in the field.

Secondly, the volume alerts students—especially graduate students—and faculty to methodological issues deserving of research attention.

The volume presents wide-ranging, diverse perspectives. Their common thread is a focus on the "how to" of EA and IA. We expressly invite readers to peruse "alien" IA domains. We believe the field is ripe for cross-fertilization of approaches. For instance:

- Health care technology assessment bespeaks key elements of strategic environmental assessment (SEA).
- Environmental technology assessment [bridging technology assessment (TA) and EA] is addressed by Strohmann and Roper/Porter.
- Gabocy shows intersecting ecological and health facets of risk assessment (RA).
- Shinn and Meier raise data and modeling issues with wide implications in EA and IA.
- Brown's "environmental overview" and "decision- scoping" offer exciting new approaches that could dramatically enhance EIA and SEA processes.
- SEA (i.e., assessment of programs, plans, or policies) undertones and overtones pop up repeatedly (check the index!).

This is an experimental volume. If it is well received, it may be worthwhile to repeat it on a regular basis, perhaps with a rotating focus (e.g., IA methods one year; other environmental analysis tools another year; developments in adjacent domains in a third year). The editors expressly invite suggestions on how to enhance its usefulness, topics to be covered, and nominations of potential future contributors.

Here are selected messages delivered by the papers. The papers are clustered into seven sections according to their focus.

Perspective on the Field

This special paper shares the insights of the man most recognized with crafting the National Environmental Policy Act of 1969 (NEPA) on the motivations for the Act, its intents, and its results.

Lynton Caldwell provides perspective on over twenty-five years of NEPA. Neither the declared principles nor the substantive sections of NEPA have been meaningfully implemented. NEPA has been treated as procedural legislation, amplified by the Council on Environmental Quality guidelines which were then elevated to regulations having the status of law in 1978. However, in this guise NEPA has probably had the greatest international impact of any American law. Caldwell summarizes six key lessons from the U.S. experience.

Overviews

This section offers five papers which, by their nature, stretch across our other sections. The first two reflect upon the performance of EA in developed economies, the third presents a contrasting view of recent changes in Chinese EA practice. The fourth paper provides a marvelous overview of the methods—the tools—available to perform EA and IA. "Sustainable development" is a refrain heard often these days, in general and in the papers of this volume. Goodland's paper poses critical environmental sustainability concepts which can guide various EA approaches, especially strategic environmental assessment (SEA), to support sustainable development.

The International Study on the Effectiveness of Environmental Assessment is a landmark effort to assess the state of the field involving many participants from a number of countries over the past several years. Directed by Barry Sadler, initiated and supported prominently by the Canadian Environmental Assessment Agency, and facilitated by IAIA, this study reviews EA practice and offers suggestions on improvement. Barry Sadler's paper here presents the organizing concepts behind this assessment.

Barry Sadler presents a framework for the evaluation of EA along multiple dimensions. He clarifies the purposes of such evaluation in terms of anticipated improvements in EA practice. The organizing concepts seek to triangulate among policy, practice, and performance. He details principles for evaluation and practical applications.

Ralf Buckley focuses on issues in improving the quality of EIA work between the initiation of the process and its consideration in decision- making. He spotlights technical, political, and institutional shortcomings. In particular, needs for EIA improvement include suitable funding for key components (e.g., public participation); better analysts, driven by selection, evaluation, training, and accreditation; mechanisms for effective review; and mechanisms for cumulative and strategic EIA.

Li Wei, Wang Huadong, and Liu Dongxia point toward dramatic progress in the conduct of EIA in China. They suggest that nearly all building projects are assessed and considerable work is underway on advanced methods in environmental risk assessment, social impact assessment (SIA), and biodiversity IA. Key evolutionary trends are noted, horizontally, toward regional EIA, and vertically toward strategic and policy EIA.

Larry Canter arrays twenty-two types of methods against seven typical study activities to which they may be applied. He finds, in general, that simpler methods have been more useful, but also that the types of methods used have expanded over the three decades of EA practice. There is no universal method, but rather a toolkit from which several methods may be selected as appropriate to a given EA study.

Robert Goodland differentiates environmental, social, and economic sustainability as each contributing to sustainable development. He focuses on environmental sustainability, noting that the environment is so heavily used now that it is a limiting factor for much economic development. He distinguishes three degrees of environmental sustainability, as well as differences between intragenerational and intergenerational sustainability, that we need to recognize in addressing natural capital in EA.

Strategic Assessments

Strategic EA (SEA) is currently the single most important direction in EA, to quote Ralf Buckley. That is the rationale for this section of the *Methods Review*. In essence, all the papers in this section can be considered as variants on this theme—the application of EA above the project level.

Buckley and Robert Goodland pose the main challenges of SEA. The main forms of SEA address policy, plans, and programs. NEPA calls for EA of federal policies and proposed federal legislation, but implementation has been lacking. Buckley identifies the same four major components to an effective SEA or EA framework: triggering mechanisms, technical assessment, decision processes, and follow-up. Technical assessment and decision influences are more challenging than for EA, but viable. Buckley explores SEA practice with respect to treaties (e.g., NAFTA), geographical (e.g., regional) SEA, temporal SEA (planning), technology (i.e., Technology Assessment), and generic projects, among others. Goodland examines, among others, sectoral SEA (considering most potential projects proposed for an industrial sector), privatization of formerly governmental functions, and national budgets. He particularly notes the potential of SEA for trans-national issues, including the UN Biodiversity Convention and the Convention on Climatic Change.

Ralf Buckley and Carolyn Hunsaker each address key aspects of cumulative environmental impact assessment. Consideration of cumulative impacts traces to NEPA and its definition of them as "the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions." Buckley draws attention to the legal and political deficiencies in triggering cumulative impact assessment. EIA and pertinent planning processes need to address cumulative impacts. Then, decision making needs to incorporate cumulative impacts consideration in a rich framework able to consider tradeable rights, uncertainties, etc. Hunsaker directs attention to needs in performing cumulative impact assessment. She notes two useful frameworks—one contrasting management and cumulative impact boundaries, the other ecological risk assessment. She reviews pertinent techniques and points to the need for sustained effort in both science and policy arenas to handle cumulative impacts.

John Bailey and Stephen Renton focus on policy EA/IA. They note that mandates and methods for policy EA are at early developmental stages. In reviewing experience in conducting policy EAs, they caution against facile acceptance of SEA (including policy EA) as an extension of EA. Drawing upon Boothroyd, they call for the evolution of policy IA that draws from both project-level EA approaches and from the ostensibly more integrated policy analysis approaches that assess policy options and outcomes in terms of higher and mixed objectives.

Tom Roper and Alan Porter assert that the need for policy-relevant TA remains strong, despite the demise of the U.S. Office of Technology Assessment. Whether as TA per se, or as emergent forms of impact assessment such as SEA, broad scope assessment of the implications of emerging technologies is critical. Three recent practical guides to doing TA are highlighted.

Processes

This section's papers share a theme of "doing." They stretch from selecting methods through training. In between are two very practical innovations suggested by Lex Brown proposing radically "cheaper, better, faster" ways to tackle EA. Those are followed by examination of the integration of NEPA and another legislative mandate to weave IA together with ecological management.

Elsa João treats Geographic Information Systems (GIS), an enabling approach apt to remake the conduct of EIA. The following two papers address the before (triggering) and the after (post-project monitoring). These are followed by a case illustration of an integrated software-based approach—a potential harbinger of EA in the coming decades.

Ron Webster makes the case for relatively simple methods for EIA. He chooses the Economic Impact Forecast System (EIFS) to exemplify such a method. EIFS uses the export base approach to regional economic prediction. It is teamed with the Rational Threshold Value Technique to provide an integrated package that includes the database, the model, and a means to measure the significance of impacts. This combination makes for an effective and popular method (U.S. Army and Air Force use) due to ease of use and efficiency, flexibility, comparability, reproducability, explainability, and defensibility.

Brown offers the relatively simple *environmental overview* as a way to accomplish many SEA (and EIA) objectives relatively painlessly. The environmental overview is a participatory, creative process to be used in the formulation stages of programs, plans, policies, or projects. It entails assembling a broad spectrum of interested parties with diverse perspectives to explore interactively seven questions concerning the social and environmental context and implications of proposed activities. He notes this can be done in as little as one day.

Lex Brown presents *decision-scoping* as key to transform IA (and also SEA) from ineffective, report-centered efforts to a dynamic process integral to development planning. Decision-scoping develops a schedule of all decisions to be made throughout the concept, planning, design, and approval cycle for a development, then identifies the environmental information required at each decision point.

Robert Keiter and Robert Adler consider the joint use of NEPA and the Sikes Act (that requires Department of Defense natural resource planning and management) to facilitate ecological management. Careful implementation of NEPA, including the use of programmatic EISs and tiering, can help accomplish the seven principles of ecological management.

Elsa João anticipates increasing use of Geographic Information Systems (GIS) (spatial databases with geo-referencing) as a tool in all EIA stages and even as an integrating framework for the whole IA process. Such use of GIS poses substantial computing and data requirements, but offers the ability to integrate various kinds of spatial information, update such information, and develop good visual displays to enrich EA and IA.

Anne Shepherd discusses how post-project impact assessment and monitoring transforms EIA from a one-time, pre-project statement to a continual assessment process. Such monitoring is not well-established, although requirements and standards for it are emerging. Various monitoring forms (including baseline, effects, and compliance) can enable auditing of mitigation measures, refinement of IA methods, and adaptive environmental management to improve project outcomes.

Ralf Buckley and Jan Warnken use Australian tourist developments from 1979-1993 as a testbed to evaluate EIA triggering and technical quality, which they find seriously wanting. Triggering mechanisms have been circumvented, baseline studies have been sketchy and inadequate as a basis for testing impacts, and testable impact predictions rare. They recommend attention to these facets, establishing monitoring programs, and better focused scoping to key on the most critical of the potential impacts for particular project types.

Carl Scott and Edward Dlugosz present the Army National Guard-Environmental Compliance Assessment System (ARNG-ECAS) as a model environmental auditing package. This software provides a systematic approach to identify non-compliant conditions, develop corrective actions, identify resource requirements, and track implementation of corrective strategies.

Christian Strohmann addresses two interesting issues—the emergence of a variant of TA, *environmental TA*, and the need for considered attention to *training*, with primary focus on United Nations Environment Program initiatives.

Risk Assessment

This short section seeks to open communications between the risk assessment (RA) and EA/IA communities. The first paper contrasts five RA guidelines and the second considers risk communication issues in EA.

Terese Gabocy compares five sets of *RA guidelines* (U.S. Environmental Protection Agency (EPA) for Superfund, EPA for ecological RA, U.S. Army, U.S. Department of Energy environmental restoration, and European RA of existing substances) in terms of ecological and human health risk considerations.

Linda Rahm-Crites addresses risk communication in EA. The challenge is to present risk information in EISs so that publics and decision- makers can readily understand it. She reviews emergent approaches to provide risk comparisons, ways to convey uncertainty, and approaches to deal with framing effects. New approaches to risk communication are promising, but agencies are hesitant about adopting them, in part due to concerns about time, money, and effort involved.

Domain-Oriented IA

This section focuses on methods as applied to particular IA "disciplines." The eight papers address social, economic, climate, health, ecological systems, and environmental justice.

Nick Taylor, Colin Goodrich, and Hobson Bryan address SIA or social assessment (SA). SA has flourished internationally in the last five years. It has become well-established in national (e.g., New Zealand) and other legislation, and is now a part of IA for most projects, increasingly for programs and policies. Blending participatory methods with SA in EA can achieve high integration of social-economic and bio-physical assessments. The authors note several new approaches, including a soft systems approach and a specific technique to link bio-physical and social variables in a "web" of cause and effect relationships. Projection of impacts remains a particular challenge.

Larry Leistritz provides a thorough review of both the basic principles and the latest practices in analyzing *economic and fiscal* impacts (i.e., on governments) of projects, programs, and policies. The paper indicates many references to the application of particular methods in various situations.

Taff and Leitch point out that valuation of non-market goods and services relies on three main methods; all key on the worth of derived services, not the asset itself. They summarize a vast literature, noting useful compilations available.

Roslyn Taplin describes the state of climate IA—a policy tool to address the problems of human-induced climate change. Since 1988, the Intergovernmental Panel on Climate Change (IPCC) has synthesized the work of hundreds of researchers. Several approaches are contrasted—in particular, the Integrated Assessment Modeling Approach and the Integrated Assessment Framework Approach, differing in that this utilizes both modeling and other empirical information. Taplin notes the Mackenzie Basin Impact Study as a pioneering example of integrated climate IA work addressing terrestrial and water ecosystems, human settlements, and policy issues.

Reiner Banken explores the intersection of *public health* and EIA. He suggests that the traditional public health emphases on toxicological elements via RA can be broadened. “The new public health” framework encompasses collective determinants of health—namely social influences, environment, and policies—that pose a richer perspective on health risks to be probed through EIA.

Cliff Goodman lays out a ten-step approach to *health care TA*, an important and growing set of assessment activities that may be technology-oriented, problem-oriented, or project-oriented. For each step he points out component activities and methodological issues in doing it well.

Jo Treweek and Pete Hankard discuss the process of ecological impact assessment in the context of strategic ecosystem management concerns. Development of ecological indicators together with integrated monitoring of biological resources will aid in addressing biological diversity, mitigation vis-a-vis tradability of natural resources, and coming to grips with cumulative ecological impacts.

Cory Wilkinson addresses environmental justice IA, mandated of U.S. agencies by Executive Order. It involves three key components: demographic analysis, IA, and community involvement, and can be incorporated into NEPA processes. Federal agency judgment must be made as to whether a minority or low-income population would be disproportionately impacted. This entails comparative analysis among populations, i.e., determining the proportion of the impact on an “average” resident that would be experienced by minority or low-income community members. Attendant issues include consideration of social impacts, along with health and environmental effects, under both normal operations and accident scenarios. GIS is a particularly effective tool in linking IA data to different populations. Environmental justice IA has been achieved with varying degrees of success.

Models in Environmental Impact Assessment

Diane Meier recommends that managers get involved in assuring that the most appropriate *model* is used for each IA area (e.g., water quality, radioactive release dispersion). Desirable model attributes include public availability, appropriate assumptions, data requirements, and agency approval. Peer review of the model selection and input parameters is also suggested.

Joe Shinn points to the value of a health RA, at least at the screening level, to EA. The beginning of a valid health RA is good estimation of the *source terms* (chemical releases to the air). He suggests how to estimate routine and other releases (e.g., from open burning/open detonation of residual explosives).

Julie Zoller makes the case for appropriate consideration of *transportation* activities in EAs, including those in which transportation is not the primary activity. She notes that health RA models may be of use. Two relatively new areas of concern may be terrorism-induced risks and environmental justice considerations. Transportation considerations are exemplified for two recent EIAs on the transportation of radioactive materials.

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Implementing Policy Through Procedure: Impact Assessment and The National Environmental Policy Act (NEPA)

Lynton K. Caldwell[1]

Abstract

During the 1960s, there was an upsurge of concern among advanced industrialized nations over unforeseen adverse effects of technological innovation. The concern led to adoption of methods for estimating and forecasting the impacts of technology and development on public health and safety, social and economic stability, and the environment. Among these were technology assessment, risk assessment, cost benefit analysis, and environmental impact assessment. In the United States, the assessment of the effects of public projects or proposals having a major foreseeable impact on the environment became statutory law under the National Environmental Policy Act of 1969. This statute, and the methods it stimulated, has possibly had the greatest international impact of any American legislation.

Key Words: NEPA, CEQ, procedure, implementation, science, judicial review

Following World War II, there was an unprecedented upsurge of economic and technological development in the U.S.. Unlike Europe and East Asia, the U.S. had no damaged economy or infrastructure to repair. Its wartime industries —notably in chemistry, electronics, and atomic energy —were rapidly adapted to peacetime purposes. New technologies, untested for residual effects, were greeted with uncritical optimism. Agriculture was revolutionized by potent new pesticides, herbicides, and inorganic fertilizers. Insect vectors of disease, such as malaria, could now be suppressed. Abundant, clean, and cheap energy would soon be provided by atomic fission. In summary, science-based technology would permit rational human management of the world economy and the natural environment.

By the end of the 1950s, this utopian vision was fading. Health effects from exposure to nuclear fall-out —notably from atmospheric weapons testing —resulted in heated public controversy. Ecological disasters from chemical pesticides were dramatized by Rachel Carson, in *Silent Spring* (1962). Investigators found persistent unbiodegradable toxic residues in vegetables, fruits, fish, and drinking water sources. Population growth and affluence were accompanied by increased air and water pollution, although advocates of economic growth denied a cause-effect connection. At the same time, people saw a steady deterioration in the quality of their environment at the very time when many of them could afford a more generous lifestyle. The result was public discontent, reflected in the news media and subsequently in the agendas of perceptive politicians. But not until the mid 1960s did a concept common to the range of discontents over air and water pollution, depletion of wildlife, hazards of pesticides, atomic radiation, and loss of wilderness values converge as environmentalism.

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Throughout the 1950s and '60s there was general popular and political confusion over policies relating to natural resources and what was coming to be distinguished as the "environment." Initially the remedies for public dissatisfaction were perceived to be economic. But whatever the cause, a concerned public was demanding preventative action mandated by law. Polluting industries and local governments resisted the imposition of new costs, so compromise legislation resulted. Beginning in the 1950s a series of bills were introduced in the United States Congress to reduce waste and abuse of natural resources and to control air and water pollution. Remedial measures were initially disconnected and ad hoc. New scientific evidence and popular dissatisfaction caused an upward ratcheting of amended environmental regulations.

In 1959, Senator James Murray of Montana introduced the Resource and Conservation Act, which was intended to provide a more comprehensive and integrative approach to national policies regarding the nation's public lands and natural resources. It was the beginning of legislative efforts that led to the National Environmental Policy Act of 1969 (NEPA), but environment was not yet an articulate issue. Lyndon Johnson spoke of the new conservation which, in fact, subsequently became environmentalism. Johnson's 1965 White House Conference on Natural Beauty may be taken as a division point between natural resources conservation (essentially an economic utilitarian objective) and environmental quality which was an ecological preservationist concept.

The Murray bill and its successors patterned their proposals after the format of the Employment Act of 1946 and the Council of Economic Advisers. This legislation provided a three-member council appointed by the President, located in the Executive Office of the President, with responsibility for advice to the President and for preparation of an annual report—anticipating the format of NEPA and the Council on Environmental Quality. But NEPA differed fundamentally, in that it contained a much more comprehensive declaration of policy and an action-forcing provision: the environmental impact statement.

Origins of Impact Assessment

No social process or method emerges out of nowhere. The origins of impact assessment are multiple, as are its applications to different aspects of the environment, broadly defined. The effects of technology (also broadly defined) and of its products became a focus for public apprehension—conspicuously so in the 1960s. Public health policy had long been concerned with cause-effect relationships, but, other than sanitary protection from infectious disease, medical diagnosis tended to regard the environment as largely neutral. After World War II, direct and indirect consequences of new and unfamiliar industrial and biomedical technologies stimulated research into their impacts upon individuals, societies, and nature. Cost-benefit analysis had been used to establish an appropriate balance between the monetary costs of a project and its alleged benefits. However, this technique has frequently fallen short of real impact analysis. Costs and benefits have often been narrowly construed and monetized—whatever couldn't be measured and priced being omitted from the calculations. It has been relatively easy to skew the inputs and outputs to obtain a "politically preferred" ratio.

The development of environmental impact analysis and assessment pursuant to NEPA greatly expanded the scope and content of cause-effect analysis. Other analytic techniques such as technology assessment and risk assessment were developed to inform—but not necessarily to determine—policy. Environmental impact assessment (EIA) mandated by NEPA was specifically intended to influence policy and to force action on the principles enumerated under Title I of the Act. It was intended to bring ecological rationality to the policy process (Bartlett 1986, 1989; Caldwell 1991).

Procedure as Policy

The National Environmental Policy Act of 1969 appears to have been the first national statute to mandate an assessment of the environmental impact of proposals for legislation and other major governmental action significantly affecting the quality of the human environment. This assessment was required to be reported in a detailed statement by the official responsible for the proposed action, and to respond to the following provisions:

- The environmental impact of the proposed action
- Any adverse effects which could not be avoided should the project be implemented.
- Alternatives to the proposed action
- The relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity, and
- Any irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented.

In addition to the impact statement, NEPA (PL 91-190 §102 2[a]), required the federal agencies to "utilize a systematic, interdisciplinary approach which will insure the integrated use of the natural and social sciences, and the environmental design arts in planning and in decision making which may have an impact on man's environment." The agencies were also required to give appropriate consideration to unquantified environmental amenities and values.

Without these action-forcing provisions, NEPA would be little more than rhetorical exhortation. The agencies would have continued to be guided only by their particular statutory missions—which took little or no account of environmental impacts. NEPA, in effect, amended all agency missions, its provisions becoming part of their basic authorizing legislation.

The fundamental purpose of NEPA was to establish its declared principles (§101) as public policy in the United States. But owing to peculiarities of the American political system, the interpretation and enforceability of its laws are vested by popular consent and constitutional interpretation in the judiciary. The federal courts have firmly insisted on literal conformity to the impact statement provision, including its requirement for public disclosure. The courts have declined, however, to review implementation of the substantive sections of NEPA—which were the very reasons for its enactment. The substantive goals were set forth as broad objectives of policy. They did not specify strict mandatory performance, so implementation remained at the discretion of the administrative agencies unless their actions clearly violated the Act's intent. There deliberate disregard for NEPA principles is evident. The Court of Appeals for the District of Columbia decided in the *Calvert Cliffs* case (1971) that the courts could reverse agency decisions. The judiciary does not hesitate to override congressional and agency action on issues involving civil rights and property rights declared by the Constitution. But environment has no constitutional protection, and its treatment in litigation and judicial review is unpredictable, with deference usually accorded to agency discretion, provided the environmental impact statement is found acceptable. In effect, the U.S. courts have treated NEPA as procedural legislation, as if it were an extension of the Administrative Procedure Act of 1946. This is a miscarriage of the intentions of the framers of NEPA, but it underscores the importance of the impact statement requirement as a means to redirect policy through procedural reform.

Established by NEPA, the Council on Environmental Quality (CEQ) has primary responsibility for overseeing implementation of impact assessment. Initially, after consultation with the agencies, it issued guidelines for meeting the impact assessment mandate. In 1978 President Carter, by Executive Order 11991 , elevated the CEQ guidelines to regulations having the status of statutory law. By explication and elaboration of Section 102 2[c] of NEPA, the regulations, in effect, could open the way to consideration of the comprehensive effect, if not the substance, of agency proposals. Where a significant environmental impact was found, an agency could no longer conceal its intentions and plans from other agencies or the public. Thus the impact statement requirement, implemented by the regulations, has had the effect of bringing agency policies into closer conformity with NEPA's substantive provisions than has been obtained through judicial review.

To a significant extent the declared policies of the U.S. federal agencies affecting the environment have been influenced by the impact assessment requirement. The actual integration of NEPA principles into agency action is another matter. In practical terms NEPA has never enjoyed a high priority with either the President or the Congress. The CEQ, although located in the Executive Office of the President, has generally been treated with presidential and congressional indifference and denied funding adequate to fulfill its statutory mission. The enforcement of NEPA has been suspended occasionally at the behest of big timber and oil interests.

Environmental quality in principle is a priority in American political life—but not a high priority. Several attempts have been made to abolish the CEQ—notably under the Carter and Clinton presidencies. In effect, NEPA can be marginalized, but not easily repealed—an action that neither of the major political parties has been willing to undertake directly. Opinion polls indicate that most Americans are firmly supportive of the NEPA intent, despite the fact that many are unfamiliar with the actual legislation and that its objectives may not be in the forefront of their concerns on election day.

Very few Americans (in common with the citizens of many other countries) give informed attention to what their lawmakers and public administrators are actually doing. Thus, but for the vigilance of the now numerous nongovernmental environmental groups, quiet deals and exceptions to declared policy intent may slip by unnoticed until (too late) their consequences are exposed. A mandatory impact assessment requirement providing for full public disclosure and comment offers the best prospect for sound and ecologically sustainable environmental policy. Despite the failure of the President and the Congress to fully implement the law's declared intent, NEPA must nevertheless be accounted a success and an important milestone in public policy. A survey by the CEQ and the Department of State indicated that NEPA has in various degrees influenced legislation in more than eighty countries—making it probably the most widely emulated American statute. And the most emulated provision of NEPA appears to be the concept of environmental impact assessment.

Defining Policy Choice through Impact Assessment

The purpose of NEPA, according to Senator Henry Jackson (its principal sponsor), was to cause agencies to reorder their priorities and to internalize in their policies and procedures an informed concern for the environmental consequences of their actions. Borrowing Marshall McLuhan's description of the impact of telecommunication on the receiver, "the medium is the message," we may say that the medium of a truly valid impact assessment coveys a message to policy-makers. Although EIA under NEPA does not mandate a particular policy outcome or decision, the assessment process and findings are intended to cause agency planners and decision-makers to think through a policy before acting upon it. Underlying NEPA is a belief that knowledge and rationality applied to public issues are more likely to yield results in the public interest than inadequately informed action or narrowly focused objectives.

The cumulative effect of successive impact findings and records of decision have the potential of being instructive. Projects found to be environmentally harmful or ultimately unsustainable have been modified, rejected, or even not proposed. Consideration of alternatives is required by NEPA because experience has shown that alternatives will not voluntarily be explored for politically motivated "pork barrel" projects. When linked to genuinely objective and inclusive cost-benefit and risk analysis, the findings of an EIA should also serve as a major element in PIA—policy impact analysis. The multiple pressures and constraints confronting all societies narrow choice in many areas of policy. As ever with political decisions, especially in democracies, short-term answers are sought for immediate problems with insufficient consideration of long-term consequences. EIA under NEPA requires consideration of "the relationship between local short term uses of man's environment and the maintenance and enhancement of long term productivity." Thus, if short term solutions to pressing problems are necessary, those solutions should include alternatives having the least opportunity costs and avoiding "any irreversible and irretrievable commitments of resources which would be involved in the proposed actions should [they] be implemented."

Administrators and students of NEPA confront a paradox in American values. For many people, public environmental quality is a legitimate objective provided it does not cost too much. The question is how much and what kind of costs. For many Americans the quality of the environment has always been a significant psychic and aesthetic value. For many others, however, environment in its larger sense has little relevance to their beliefs and values. Working against the values declared by NEPA are: (1) the intense individualism felt by many Americans—a residue of the pioneer spirit, (2) biblically ordained domination theory (all living things were created for man's exclusive use), (3) deep-seated, emotional commitment to absolute private property rights in land and natural resources, (4) a commercial economy in which virtually all value is measured in monetary terms, and (5) a political system in which political favors, such as subsidies, are exchanged for personal financial support from vested interests. NEPA does represent the nation's good intentions, but in appraising its effectiveness one ought not overlook the forces working against it.

Lessons from NEPA

We now have had more than twenty-five years experience with environmental impact assessment under NEPA. What can be learned from this experience to assist the more effective use of this procedure? Among governments adopting EIA, practices will differ in detail as appropriate to the political structure of different countries. Yet there have been principles and problems inherent in its generic application that merit consideration wherever EIA is undertaken (Caldwell 1987). I have identified six lessons implicit in the United States experience.

- *First*, effectively assessing environmental impacts requires an understanding of the concept of environment: a two-way multiplex relationship — not things in them selves. It is the interactive (i.e., dynamic) relationship that constitutes the environment — not merely an inventory of things impacted by human activities.

- *Second*, EIA is a means to an end—not an end in itself. As with many analytic methods there is risk that preoccupation with technique will override focus on purpose.
- *Third*, EIA requires comprehensive integrated use of the best available science, although the assessment itself is more than a scientific conclusion. There may be ethical and aesthetic considerations in an assessment beyond the reach of science. Although science may not be adequate to resolve certain questions regarding long-term consequences, the necessity for ascertaining the probable impacts of proposed action has surely stimulated research, training, theory, and application in the environmental sciences.
- *Fourth*, full benefit from EIA depends upon the internalization of the process and its findings within the structure (e.g., functions and employees) of the assessing agency. Unless EIA contributes to organizational learning and to review of agency priorities, its effective implementation is unlikely. Farming out EIA to external consultants defeats its purpose. Outside specialists may be brought into the process if integrated with agency procedures.
- *Fifth*, unless there is political will to achieve the objectives of environmental protection and enhancement, EIA will be a pro-forma exercise of little practical utility. For evidence of the presence (or absence) of political will, look first to the performance of the executive and legislative branches of government; second, look to the location and status of EIA within the structure of the governmental agencies. In addition, the EIA has sometimes been misused for purposes other than the intent of NEPA. One should look behind allegations of non-compliance with the EIA requirement to ascertain the actual objective of the plaintiffs (Caldwell 1978).
- *Sixth*, unless NEPA is understood and implemented as the main, inclusive declaration of purpose that it was intended to be, its implementation will be almost entirely procedural. EIA may continue to influence policy planning and decision making, but NEPA is also intended to advance and disseminate environmental knowledge. Title II of NEPA was intended to advance ecological research and environmental education and understanding. These objectives represent high public values but low political priorities. Title II has therefore been largely neglected. EIA has forced the agencies to show evidence of considering the full consequences of their actions, but no statutory provision compels the President to implement the law, although Article II of the Constitution, which states, "he shall take Care that the Laws are faithfully executed," would appear to do so.

In evaluating national performance in relation to these six lessons, look for action and be skeptical of rhetoric. In politics there is always rhetoric, which may be either a precursor of action or (probably more often) a substitute for action. The experience of two decades justifies a cautious assessment of the practical effectiveness of NEPA as realizing somewhat more than half the hopes of its sponsors. This would make it a success in comparison with legislation generally—a success attributable primarily to the mandatory EIA. NEPA's lack of accomplishment in other respects is not attributable to the law itself. Its substantive undertakings—notably those for which the CEQ is responsible under Title II of the Act—have not been tried and failed. Rather they have seldom been tried.

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2

The Army's Interest in Impact Assessment Methods Review: Relevance and Efficiency

Ronald D. Webster[1]
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> Full integration will occur when everyone—leaders, soldiers, families—automatically include environmental impact and execution of activities. We have instilled the warfighting ethic throughout the force, and we are now instilling an environmental ethic as well. We must incorporate environmental considerations in our doctrine...in our training...in our decision-making process.
>
> *General Gordon R. Sullivan*
> *Former Chief of Staff of the Army*

Introduction

The Army is currently embarking on its periodic review, evaluation, and revision of Army Regulation [AR] 200-2, our NEPA implementation regulation. It is indeed fortuitous to have the opportunity to collaborate with the International Association for Impact Assessment (IAIA) in presenting *Methods Review: Retooling Impact Assessment for the New Century*. The Army will benefit from the many bright scholars and practitioners, from both national and international circles who have contributed to this volume. Insights gleaned from draft manuscripts have already provided needed perspectives, and in its final form *Methods Review* will also aid us in providing subsequent implementation guidance in years to come.

We recognize that complete NEPA implementation remains unfulfilled in the first twenty-five years of its inception. Counter to its Congressional intent, NEPA has often been performed "post facto" and is, therefore, often ineffective in effecting real decisions. Excessive costs of NEPA documentation have been common. The statute itself is based largely on common sense, allows considerable agency discretion, and encourages initiative and innovation. Such flexibility should allow agencies to use NEPA as a tool that truly supports decision making in an efficient manner. The Council on Environmental Quality's (CEQ's) 1979 implementation regulations promoted and strengthened this common sense approach, calling for shorter documents and "better decisions," in lieu of "better documents." The sources of NEPA inefficiency thus lie in agency regulations and procedures (including methods), which implement the statute and CEQ's regulations.

While all agency formal guidance encourages "early" initiation of NEPA analyses in support of decision making, misinterpretations of both the statute and the CEQ regula-

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tions often lead to a long and laborious process (late in decision making and at substantial cost). Agency leadership, often uninformed of NEPA's true intent, rely on a legal and/or environmental staff whose goal of a legally unchallengeable document often overshadows the notion of a useful document for the decision-maker.

Objective

The objective of this effort is to assess prevailing views of NEPA methods, procedures, and models from the perspective of the Army NEPA practitioner and advocate, and to recommend specific courses of action that will improve the Army NEPA program with the goals of (1) better informing Army decision-makers and (2) eliminating the needless expenditure of Army funds. These two goals—effectiveness and efficiency—are particularly important to the Army, given the unprecedented reductions of Army staff and the stresses placed upon the Army budget. These actions are proposed to increase the utility of the NEPA process to Army planners and decision-makers, and to decrease costs and project or program time delays. Current draft revisions of the Army NEPA implementing regulation (AR 200-2): (1) consolidate the best parts of the old regulation, (2) incorporate new considerations required by law, other related guidelines, and Army environmental policy, (3) incorporate conventional views on the future of NEPA considerations, and (4) capitalize on current interest in the reinvention of the NEPA process to better support sound federal agency decision making. The re-invention of the Army's NEPA program revolves around strong policy (articulated by the Army regulation) followed by specific, common-sense guidance on execution of the Army's NEPA program, which is to be both efficient and effective in adhering to this policy. The policy and the guidance will incorporate many of the observations and recommendations contained in these essays.

Approach

The Army Environmental Policy Institute (AEPI) requested the International Association for Impact Assessment to solicit and publish a body of papers which would address the current methods, procedures, and tools used in the broader field of Environmental Impact Assessment (EIA). As IAIA is the premier international body of NEPA practitioners, this effort represents a true partnership between IAIA and the Army in, as the title implies, "retooling impact assessment for the new century." In cooperation with IAIA, practitioners in impact assessment contributed their current views on the state of impact assessment methods for this special publication. This updated body of knowledge was then added to the existing NEPA literature to produce and support the recommendations contained in this paper. A review of each of the essays was performed to ascertain their relevance to the Army's goals and following such evaluation, recommendations were made.

While the intended audience of the initial papers was broad (practitioners and scholars in the broader application of EIA), many implications can be gleaned from them, once placed in the context of Army practice and used to propose improvements in the state of NEPA practice in the Army. The authors of the papers are general EIA practitioners (and also represent well-recognized academic experts), but the direct implications for the Army must be based upon a familiarity with the Army that only few of these professionals possess. A thorough review of each paper was performed, and detailed policy and implementation recommendations are being formulated at this time.

The goal of this effort is to identify opportunities to produce a more effective and efficient Army process. Effectiveness improvements will focus on the required provision of the necessary information to the decision-maker at the appropriate time in the decision life cycle. Efficiency will concentrate upon the expenditure of scarce financial resources on those issues that can or will affect Army decision making, and on the saving of resources that would otherwise represent the needless expenditure of resources on issues that are not critical to NEPA or Army decision making.

Results

The review and analysis of the papers has led to identified potential improvements in the following areas:

Education

There must be a focused educational effort to inform the decision-makers in the Army, the NEPA analysts serving the Army, and the public and other stakeholders in the NEPA process. The parallels between the well-established Army decision-making paradigm and the process outlined in the NEPA statute must be fully understood. NEPA calls for nothing more than the sound, informed decision making taught in the Army leadership schools. As such, it should be more easily implemented within the Army leadership. In practice, however, this has proven difficult, and this difficulty lies in a misunderstanding of NEPA.

Caldwell discusses the deep-rooted genesis of NEPA as a means of insuring that environmental considerations are part of agency decision making. In spite of this common sense underpinning of the statute and its recognition of other agency mission requirements, there are many conventional misunderstandings of NEPA which must be addressed.

Emphasis on NEPA Analysis

The Clinton Administration's "merger" for the original Office of Environmental Policy (OEP) with The President's Council on Environmental Quality (CEQ)—establishes CEQ as the national environmental policy organization that was originally intended by the framers of NEPA (see Caldwell). As a result, NEPA has become a revitalized and important instrument of national environmental policy. To assess the current state of NEPA application in the U.S., CEQ surveyed the NEPA stakeholder community to analyze NEPA's strengths and weaknesses. They concluded that even with all its flaws, NEPA is well-supported as a mechanism to insure public, state, and tribal participation in the federal environmental decision-making process. As a result, a considerable NEPA constituency will continue to exist. The Army values this revitalization and sees the opportunity to improve the NEPA process as encouraged by CEQ in its analyses. Thus, the Army should adopt policies and procedures that optimize NEPA's application.

The NEPA process, internationally known as the EIA process, is the United States' most emulated legislative innovation (see Caldwell). Its application overseas is increasingly accomplished at the strategic level earlier in the process than the program or project-level EIA commonly associated with the NEPA process in the U.S. The international review of EIA practice (see Sadler), apart from the conclusions and analyses in the study, points to the growing international acceptance of the process as a sound support mechanism for policy and decision making.

Project Vulnerability

Many believe that the identification of significant impacts will stop a project. In fact, it is the "failure to do so" that creates vulnerability under NEPA. Impacts that are fully disclosed will never stop a project or program under NEPA, although disclosed impacts may trigger other environmental statutes which may have that effect. The decision-maker's vulnerability is not increased by the NEPA process, but an informed decision will, in fact, protect the decision-maker. NEPA can easily delay projects and programs through "injunctive relief," obtainable if the analysis of impacts is done in a superficial manner—or not done at all. In summary, the tendency to "ignore" or "downplay" NEPA creates the vulnerability, and can become a "self-fulfilling prophecy."

The Intent of NEPA

There is a lack of appreciation for NEPA's original intent to inform and assist the agency decision-maker (see Caldwell). Many view the documentation in the same context as a paper for peer review, while others see opportunity to expand the scientific knowledge base. While these developments are not to be discouraged, they should not detract from the intent of the NEPA process.

Unfortunately, they often do. Scientific uncertainty was a recognized inevitability and while NEPA makes provisions for scientific research, it is not part of the agency decision-making process. While the agency is obligated to be aware of impacted environmental resources (often requiring data acquisition) and is obligated to analyze (using good science) and disclose probable impacts, there is little direct requirement to extend the "state of the art." NEPA actions should not do so at the expense of an uninformed decision-maker. The current emphasis on adaptive environmental management (AEM), monitoring results, and adapting the project to manage impacts, is predicated by recognized scientific uncertainty. Caldwell's paper supports the use of best "available" science in the NEPA process, placing greater emphasis on the "understanding of the environment as a true dynamic process" and NEPA analysis as a "means to an end, not the end itself."

Caldwell further acknowledges that the actual legal requirements of NEPA are often less than those which have been required by the legal staff of affected agencies, as well as their colleagues in the judiciary. The required "hard look" can be much more pragmatic than the "bullet proof" approach to documentation often encouraged by the legal and environmental staff of federal agencies. Unfortunately, this bullet proof document comes too late to affect an agency's decision process. Webster discusses the use of a simple tool (inexpensive and responsive) that represents the application of a "hard look" in an efficient and effective way.

Strohmann identifies that Technology Assessment (TA) practitioners are negligent in the teaching (imparting knowledge) and training (capacity building) aspects of their discipline. In an effort to educate and make decision-makers aware, a number of initiatives are underway in the TA community. These same initiatives are applicable to the Army NEPA program: (1) methodological and organizational integration, (2) methodological training of engineers, (3) in-house training on methodology, and (4) integration into management for program directors and project managers.

Ethical Implications of NEPA

Caldwell identifies NEPA's true and most fundamental appeal to the "higher level goals of society," and that these goals must prevail if NEPA is to achieve success. This mirrors Jefferson's faith in democracy, based upon the common man's inherent capabilities for sound judgment. While this may seem to depart from the pragmatic, it is the very foundation of NEPA, assuming that an "informed" decision-maker will make the right decision. This foundation presupposes the existence of certain ethical values (i.e., concern for the environment).

Goodland (this volume) presents the case that "natural capital" (natural resources such as soil, plant, and animal species, etc.) is the hardest form of capital to replace, and that the burden of such replacement often falls upon future generations which were not part of the initial "transaction." This argument places an ethical "spin" on the notion of "sustainability." In addition, sustainability embraces "intergenerational" or "intragenerational" considerations raising the traditional questions of equity, "who benefits, and who pays." Ethical considerations aside, these are the resource issues that historically lead to instability and conflict, driving the "environmental security" component of current Defense and State Department policies.

Role of Policy

Caldwell attributes many NEPA failures to a lack of political will. While scoring NEPA's success at 50 %, Caldwell feels that this is good score (and above average for most legislation). The argument places blame for the 50 % failure at the policy level, allowing the courts to emphasize documents "de facto" instead of implementing a sound process that would lead to better decisions. While NEPA was never intended to hinder the performance of an agency's initial primary mission responsibilities (see Caldwell), there is a common perception in the Army that it does so. If this is true, it is implemented improperly (from a NEPA standpoint), and policies and guidance should adjust to insure change. This does not mean that NEPA can be ignored or minimized in the decision-making process; as by law, NEPA is a component of every agency's mission, not an additional duty (see Caldwell). Caldwell believes that full realization of NEPA can only be achieved through leadership's political will. Thus, the true value of NEPA is determined by the means through which the Army chooses to implement and utilize the statute and its regulation. Bailey and Renton promote the use of EIA to analyze policy alternatives and support policy development at a level above that of the traditional project-level EIA. If this were accomplished, the subsequent NEPA analyses (at the program and project levels) would become easier and more efficient. The will of the Army's political leadership can best be expressed through such practice and demonstration.

Integration

Caldwell calls for a process that is more fully internalized within agencies, as the growing dependence of agencies on external expertise is undermining the true intent of NEPA. This dependency removes the decision-maker and supporting staff from the process, as common contractual provisions often prohibit the day-to-day interactions with a contractor that would insure proper inclusion of environmental considerations into the Army decision-making process. In short, the fixed price scope of work leaves little incentive for adaptation and ignores the interactive nature of the decision-making process. Moreover, there is little incentive to save money in most contracts. If NEPA is to be implemented properly, an agency's cognizance and appreciation is essential. NEPA cannot effect decisions in an agency if the process is externalized through contracting. On the other hand, true integration could make NEPA a useful tool, identifying potential environmental problems early in the project life cycle, and also saving money over the long term.

The Army is currently emphasizing the "systems approach" for large projects, recognizing the value of "life cycle" economic analyses as a way to integrate environmental considerations into the already established "trade-off analyses." Li, Wang, and Dongxia identify the difficulties associated with impacts which occur later in the project/program life cycle and are difficult to foresee or address during earlier stages of the analysis process. The experience of the author leads to the development of tools which can identify constraints on the ability of particular regions (installations, in the Army sense) to accept a project at the implementation stage, the “carrying capacity” approach currently under development in the Army. Other considerations (“show-stoppers”) must also be incorporated into this life cycle concept.

Brown further attacks the notion of a “one-time document” and its conflict (through “passive non-interaction” between the project design and the assessment of its effects) with the strongly interactive nature of decision making. This “one-time,” limiting approach has become the dominant culture of much NEPA practice, focusing on the “document.” Ironically, successful practitioners have found that mitigations are more easily accepted into project plans when there is a higher degree of interaction between the environmental analyst and the design or project team, particularly if is done early and continuously (concurrently) in the project life cycle. Such interaction is productive, and it increases the value of the NEPA process, but it is discouraged by many current formal procedures. Organizational culture change will be required to rethink the relationship between environmental assessment and project/program development; changing to a vigorous (as opposed to passive) interaction, focusing on the timing and nature of all decisions that are made during the complete life cycle of project conception, planning, design, and approval. Brown quotes a study suggesting that a predominant NEPA paradigm has been “dispute creation,” not “dispute resolution”: “... a change that might have been well received and initiated on the basis of a ten-minute telephone call to the project manager, earlier in the feasibility stage, may be resolutely opposed at the end of the design stage or in the construction stage, even if supported by field studies and thick reports.” These observations support the need for (1) more interaction (integration) and (2) appropriate tools that would support the “integrated model,” or systems approach.

Brown (Overview) presents a concept of the “environmental overview” as a “coarse” tool to be used during program “formulation” identifying environmental and social impacts, and providing for the early incorporation of mitigations, feeding directly into program design iterations. Such a tool precludes the checklist mentality (usually leading to purely bureaucratic compliance) if: (1) the program is in its draft formulation stages, (2) there is sequential completion of structured “questions” in the process, (3) the process is participatory, using a broad mix of specialists, and (4) modification of the draft program is an integral part of the process. Applied to non-geographically based programs and policies, and incorporating the participation of proponents and stakeholders, this approach has increased effectiveness through project selection, abandonment, or modification. Experience has indicated that decision-makers will readily introduce modifications into a project/program when (1) the environmental issues and opportunities have been brought to their attention and (2) clear environmental objectives have been set. This tool represents a trade-off between a “coarse” (but effective) tool and a more “comprehensive” (but possibly ineffective) tool such as project-based analysis and documentation, providing rapid assessment for program formulation and illuminating needs for redesign. This paper supports the premise that a decision-maker will utilize and incorporate information if it becomes available early in the decision life cycle, even though such analysis is “coarse.”

In his other paper, Brown (Decision-Scoping) establishes the requirements of appropriate “decision-scoping”: (1) an understanding of the entire process (all components) and the “decision points” inherent in the process, (2) focus on all these decision points by all project participants, ascertaining the nature and timing of needed environmental input to support the decision making, and (3) design of the timing and content of impact analysis around these decision points. These three requirements have been met in the systems approach outlined by the Army acquisition community, and the tool concept expressed by Brown (Overview) is evident in the preliminary guidelines. Brown (Decision Scoping) proposes that, once relationships are clearly understood, "requirement streams" from the decision-maker are balanced against the "information streams" from the analyst, adjusting and refining the process in both cases. This again describes the current philosophy being adopted in the Army.

Taff and Leitch clearly articulate the challenge that will face the Army in life cycle economic evaluation of environmental considerations. The ability to attach economic valuation to many environmental concerns has proven elusive in the past, and attempts at this valuation approach have been controversial. While current Army emphasis has centered on the evaluation of hazardous materials and their cost implications along the system life cycle, other major "cost drivers" (in the implementation or disposal phases of the life cycle) will prove much more difficult to address.

Banken proposes the inclusion of health and safety into the NEPA process, a trend which is already evident within the practice, driven predominantly by the potential effects of radiological/toxicological releases. The emerging conceptual "new public health" will stress collective determinants of health. If NEPA becomes the mechanism, the health promotion approach must be integrated into NEPA guidance. From an Army perspective, the integration of environment, health, and safety is underway and such integration is being promoted. With the emergence of a more active approach to the improvement of health conditions in affected communities, these considerations will become more akin to the social impact assessment considerations that began to emerge in the EIA field in the 1980s. The evaluation of impacts will turn on whether a given program or project is improving the local conditions or making them worse.

Shinn also calls for the integration of health risk assessment within EIA, particularly in cases where hazardous/toxic materials are involved. This paper suggests the need for a simple screening model early in the EIA process, supported by a more detailed, sophisticated model when the screening indicates a need. The notion of a more-rigorous analysis of model inputs is well-taken. Many academics concentrate on internal model variables and approaches, and the inaccuracies which result often lie in the input data selected to drive the model.

EA/ES Quality

The measure of quality for the EIA process is addressed by Sadler. This requires both a measure of technical merit and a measure of utility. One is dictated by the degree of public and scientific acceptance, while the other is internal to the agency itself. Agencies choose the degree to which NEPA analyses and documentation are used in the decision-making process. Sadler calls for a systematic approach, in both aspects of the quality equation.

The issue of trained and qualified staff for environmental analysis has frustrated the Army program for over two decades. Buckley addresses the overall quality of EIA analyses and documents, discussing funding, professional standards, consultation, and review. These personnel issues are particularly critical to the Army during the current periods of personnel and budget reductions. Buckley concludes that a contractor's primary competitive edge lies in the ability to get the analysis and documentation done quickly. This is often afforded greater value in the bidder selection process than quality (experience with EIA) or cost.

Buckley and Warnken identify the lack of baseline environmental data as an impediment to quality NEPA documentation. Such baseline data issues affect not only the quality of the process but timeliness (effectiveness) as well. This is a major reason for the lack of responsiveness to the Army decision-making processes. This is particularly unfortunate given the number of statutory requirements that exist for the collection of this data independent of NEPA. Webster illustrates the use of a tool which relies on readily available baseline data. While the particular application is unique (having a readily available, centralized source of data to support the tool), other similar approaches may exist, improving the quality of analyses and documentation in such cases.

As a mechanism for further improving EIA quality, Buckley (Improving the Quality of EISs) recommends a review process that is already in place in the United States: EPA's review and scoring of all EISs. While Buckley and Warnken despair of the quality of analyses in support of tourism analyses in Australia, there is little applicability to the improvement of the Army NEPA process—that is, outside of their identification of the need for specific NEPA tools to improve the process. These tools could be specific to both NEPA and the Army's programs, bringing better quality to the results and aiding the efficiency and effectiveness of the process along the way.

Gabocy and Ross identify the need for combined ecological and human health risk assessment in the EIA process. The use of risk assessment models and methodologies is becoming common in EIA practice, and it is being incorporated into Army NEPA guidance at present. As their essay implies, the challenge is in matching the tool to the specific Army application at hand, based upon the content of a given methodology, availability of software and data to drive the model, and other practical considerations of efficiency and effectiveness; and guidance in the use of the appropriate tool for each given application.

Taylor, Goodrich, and Bryan stress the value of scoping (public participation) to both (1) establish context and (2) link social considerations to related biophysical considerations in the overall EIA process. Such an approach can lead to the consideration of "issues" as opposed to "data"; allowing the proponent of an action to manage stakeholders (participants) in a positive way instead of simply reacting to them; shifting the emphasis from a purely predictive mode and relying more on post-project monitoring and evaluation (long term interaction with the impacted public). Such improvements to the Army process will depend upon better management of the scoping process under NEPA, and, if managed properly, could reduce cost delays associated with NEPA analyses and documentation, thereby focusing on important issues.

Goodman deals with a specialized form of technology assessment, focusing on the following general steps:

1. Identify assessment topics
2. Specify the assessment problem
3. Determine locus of assessment
4. Retrieve evidence
5. Collect new primary data (as appropriate)
6. Interpret evidence
7. Synthesize/consolidate evidence
8. Formulate findings and recommendations
9. Disseminate findings and recommendations
10. Monitor impact

Step 2 deals with the requirement to specify clearly the problem(s) or question(s) to be addressed; affecting all subsequent aspects of the assessment. Step 3 allows decision-makers to "make or buy" all or certain portions of an assessment game plan. Responsibility and level of detail for an assessment depends upon the nature of the problem, resource constraints, and other factors. These steps could prove important to the reinvention of the Army NEPA process to bring about greater efficiency, as they insure (1) focus on the appropriate issues and (2) the use of resources to address only those issues that are important. This could lead to the better use of scoping and public participation to structure the content of the subsequent analysis process. Once an EIS (and sometimes an EA) is agreed on, the production of the document is often on a set course, regardless of the actual issues and the true "showstoppers" associated with the action; often at the expense of the issues that are truly important.

Wilkinson summarizes emerging environmental justice requirements: (1) demographic analysis, (2) impact assessment, and (3) community involvement. These stages deal, respectively, with (1) identification of minority and low-income populations, (2) somewhat traditional impact assessment focused on "disproportionate" impacts upon those communities identified, and (3) the full, open participation of those affected minority and low-income populations in the EIA process. The content of this paper is already being incorporated in Army guidance and policy.

Meier identifies the reluctance of "impact analysis managers" to deal with the technical issues, a major problem in the federal agencies where contractors and consultants are the technical contributors to the NEPA process. This tendency to "defer to the specialist" confirms that technical content and interpretation of the analysis is only weakly represented in the agency decision-making process. This lack of appreciation and comprehension of technical issues is a fundamental shortcoming of current NEPA practice. In a time of budget reductions, this shortcoming may become even more acute, placing analysis even further from the decision-maker. Meier further discusses relevant criteria for the selection of a model: (1) validated through independent peer review, (2) fully documented, and (3) available to the public; and discusses the compromise that must always be struck between model selection and the availability of data. Meier identifies the tendency of specialists to pick "models of comfort," models with which the analyst is familiar or which are readily available. These models are often dictated by short timelines and financial constraints, which lead to the use of a model that is poorly suited to a specific project. Such risks should be eliminated early in the project, insuring that the appropriate tools are being used at the outset.

Meier's essay highlights the major fallacy of the "contracting out" philosophy, a lack of understanding by the federal staff. This staff member must function as the "resident expert" long after the contract is completed, regardless of their tendency to defer or to relinquish these responsibilities to the contractor/consultant. The inevitable consequence of such deferrals is an initial lack of credibility and an eventual erosion of public trust in the agency. This situation is at considerable odds with the Congressional intent of NEPA (Caldwell). Agencies will always be held responsible for agency decisions. The inability of agency personnel to understand, explain, and defend technical analyses and decisions must be addressed by both (1) the education of those agency staff with responsibility for the projects and (2) the cultivation of technical scientists (and methods and tools) which are understandable (or potentially explainable) to the manager, the decision-maker, and the public. The technical analyst unwilling to educate the EIA manager will probably also fall short at a public hearing. The manager who cannot explain and defend the basis for an agency decision will be of little value as the project is implemented. There is considerable need for professionalism in either case.

While the trade-off between the use of simple models and their inherent compromising assumptions is valid, this does not mean that simple models are not applicable or desirable to the Army NEPA program. Many of the simplifying assumptions are acceptable, given the subsequent ability of a simple model to engage the decision-maker at the appropriate time of the project life cycle. The firm appreciation for the project/

program must be established prior to the selection of any model. A model that is not supported by sufficient input data is of little value, and too much adaptation of data (as a surrogate for the correct data) can lead to a lack of credibility.

Zoller presents the concept of project “prescreening” which can eliminate a number of major alternatives on purely practical grounds before actual impact analyses commence. The use of empirical data is encouraged to the greatest extent possible, minimizing the conservative assumptions that must be made in the absence of such data and the often unrealistic (overstated) potential impacts that can result.

Public Participation

Linda Rahm-Crites discusses communication aspects of the NEPA process, focusing on the articulation of uncertainty, which is essential for interaction with the public and other stakeholders. Referring to the CEQ regulations, she discusses the development of the message and public participation. Observing that “people process new information within the context of their existing beliefs,” it becomes important that communicators insert their message into the current state of the recipient’s knowledge and beliefs, often developed with a given cultural setting; leading to shortcomings in the traditional approach advanced by Slovak to establishing perspective among a lay audience. She identifies “two-way communication” as a potential tool, recognizing the right of citizenry in a democracy to “participate in decisions that affect their lives, property, and the things they value”. Within this context, the two priority issues are (1) integrating outside publics into agency decision-making and (2) communicating with diverse ethnic and socioeconomic groups; creating “grassroots” partnerships to offset the recent growth in the public distrust of some federal agencies. Instead, the goals is to create an opportunity for the “social amplification of trust.” Such approaches may be difficult, as there will be a reluctance on the part of agencies to open decision making to the public, in spite of its Constitutional and statutory basis.

This supports the collaborative principles set forth by Keiter and Adler for the successful implementation of sound ecosystem management. Army communities should easily become natural Army constituencies capable of “amplifying social trust. ” The Forest Service has documented experience in which “bullet proof” NEPA documents were challenged at the same time that poor documents received little comment within a different Forest Service region. Investigation revealed that some communities placed little emphasis on the NEPA document, trusting the openness and intentions of the local agency representative, while some distrusting communities had come to rely on written documentation. If the Army can build a receptive “existing belief,” much of the Army’s NEPA work will become easier. Such principles, as those presented by Keiter and Adler, all point to NEPA as an integrating process, one which ensures the analysis of necessary issues and allows open public and multi-agency interaction within the Army planning process. While such a process need not infringe on the Army’s mission (and NEPA recognizes the predominant role of that mission), the interaction with other regional players will be both a challenge and an opportunity.

Taylor, Goodrich, and Bryan stress the value of scoping (public participation) to both establish context and link social considerations to related biophysical considerations in the overall NEPA process, leading to the consideration of “issues”(as opposed to “data”) and allowing the proponent of an action to manage stakeholders (participants) in a positive way instead of simply reacting to them. Such an approach will shift emphasis from a purely predictive mode and rely more on post-project monitoring and evaluation (long term interaction with the impacted public). This will require better management of the scoping process under NEPA, and, if managed properly, could reduce costs and delays while focusing on important issues.

Banken proposes the inclusion of health and safety into the NEPA process, a trend already underway within the Army. Such inclusion will require a greater degree of social interaction and an implied interest in changing conditions. With the emergence of a more proactive approach to the improvement of health conditions in affected communities, these considerations will become more akin to traditional social impact assessment considerations, which rely heavily on public interaction.

Goodman deals with a specialized form of technology assessment, focusing on the following general steps in this specialized process. Two steps of interest in his process ("specify the assessment problem" and "determine locus of assessment") are perhaps best addressed in the public participation aspects of NEPA. A subsequent step involves proponent analysis of these other steps, forming a "game plan" for the remainder of the assessment process, thus controlling the level of detail—depending on the nature of the problem, resource constraints, and other factors. Such an approach could bring about greater efficiency, as it ensures (1) focus on the appropriate issues and (2) the use of resources to address only those issues that are important. The current regulations and guidance which govern the Army NEPA program encourage such steps through better use of scoping and public participation to structure the content of the subsequent analysis process, thereby eliminating issues irrelevant to the decision and focusing instead on those which are truly important.

Regional Analyses

The implications of increased "regional" considerations in EIA (discussed by Buckley in terms of SEA) are very significant for the Army. The Administration and Department of Defense are committed to the concept of regional ecosystem management (REM), and these considerations will dramatically change the tools and methods upon which Army NEPA tools must be based. Li, Wang, and Dongxia present recent Chinese experience in the analysis of impacts covering the much larger geographic areas that REM, biodiversity considerations, and cumulative impact analysis (CIA) will require; recommending the development of specialized tools, under the umbrella of a true "systems engineering" approach, integrating all aspects of decision making, including stakeholder involvement. The discussions of Hunsaker and Buckley (CEA) reflect upon CIA, leading to the further "regional" analyses, with ramifications for the Army in terms of costs and benefits (efficiency and effectiveness). While REM may stimulate true incorporation of all stakeholders toward the achievement of common goals, it will be difficult, and it will require a new set of tools. Hunsaker elaborates on such tools in the context of CIA: (1) monitoring tools, (2) ecological indicators, (3) cause-effect relationships and models for use at a regional or ecosystem scale, (4) tools to account for the spatial heterogeneity of data at larger scales, (5) theory and data to account for the effects of spatial heterogeneity, and (6) understanding of the errors associated with necessary data aggregation, the use of remote sensing, and the use of such tools as GIS. Essays by Hunsaker and Keiter and Adler discuss the expansion of both geographic and temporal boundaries as a result of CIA requirements.

The tool discussed by Webster can be used regardless of the size of the region being analyzed. In fact, the theoretical basis for the model becomes more sound with a larger region. While the input data to drive the simple model may still be difficult in the context of CIA, it is not as formidable and foreboding as alternative approaches, such as those discussed by Leistritz. The nationwide database is readily available, regardless of the size of the region, and extensive additional baseline data acquisition is not required. This does not mean that the models and tools discussed by Leistritz are inferior, just potentially more difficult to use in the larger regional context; and the model presented by Webster is an "aggregate" model, lacking in detail and comprehensiveness.

Keiter and Adler envision that REM will better address the needs of realistic impact assessment (and the futility of limiting such analysis to the geographic confines of an Army installation). In addition, they establish the need for "programmatic" approaches in REM applications, allowing for the "tiering" of subsequent analyses, once regional objectives are established and site-specific analyses can commence. The seven principles for the ecosystem management concept as presented by Keiter and Adler are:

- Common ecological management goals should be socially defined through a collaborative vision process that involves all interested participants and that incorporates ecological, economic, and social considerations.
- Given that most ecosystems and watersheds transcend conventional geopolitical boundaries, ecological management requires coordination among federal, state, tribal, and local governmental entities as well as collaboration with other interested parties.
- Ecological management policies and decisions should be based upon integrated and comprehensive scientific information that addresses multiple rather than single resources.
- Ecological management seeks to maintain and restore biodiversity and ecosystem integrity.
- Ecological management involves management at large spatial and temporal scales that correspond to ecosystems and watersheds.
- Given the finite nature of public funds and other resources, ecological management enables agencies to engage in careful targeting to select achievable solutions and to allocate resources efficiently.
- Ecological management requires an interactive, adaptive management approach to account for changing goals and values and new scientific information concerning ecological conditions.

These principles (strong on collaboration) all point to NEPA as an integrating process, ensuring the analysis of necessary issues and allowing open public and multiagency interaction within the Army planning process.

Monitoring and Mitigation

Shepherd identifies two traditional reasons for post-project monitoring associated with NEPA: (1) to determine if declared mitigations were implemented and (2) to determine if the mitigations were successful. These two evaluations strike at the heart of NEPA effectiveness, for, without such measures, the Army NEPA program cannot be evaluated. Furthermore, if it cannot be evaluated, its value cannot be established, and a program without established value cannot be sustained. NEPA is currently viewed as an "administrative hurdle" and, unless value can be established, it will remain so.

Shepherd additionally presents the recent shift of NEPA philosophy toward adaptive environmental management (AEM), which will place greater reliance on monitoring to account for scientific predictive limitations. AEM will make NEPA analysis more pragmatic and will also place a greater dependency on post-project monitoring and adaptation of the project to account for monitoring results. The challenge to the Army will revolve around the use of tools and processes that can bring efficiency to (1) the monitoring of projects, (2) analysis of the data to derive the appropriate information, and

(3) the modification of policy and procedures to effect process improvement.

Dlugosz and Scott present the evolution of management toward measures of organizational performance and the use of the Army Environmental Compliance Assessment System (ECAS) as a management and oversight tool. This approach can be effective in establishing the two objectives of post-project monitoring which Shepherd presents. Such measures are necessary elements of ongoing business process reinvention, applying to the NEPA process. Results should be used to improve the process, eliminating those mitigations that are ineffective and improving others. More importantly, the proposed process will provide open assurance to the public that mitigations are serious Army commitments, and this demonstration will go far toward establishing and maintaining the public trust that will be important in the future (particularly in peacetime).

Sustainability

Goodland's treatise is firmly rooted in the current attempts to link environmental issues to global security, led by the Department of Defense and the State Department. He characterizes resource constraints as ultimate limitations on the political leadership of nations, distinguishing between "intergenerational" and "intragenerational" resource issues (sustainability issues) that can lead to regional instability. This instability may be due to numerous issues, but regional economics and environmental quality are both present in most cases, as they are often interrelated. NEPA, or a similar analysis method, might shed light on alternative strategies early in the evaluation of alternative actions at this level. This is the essence of the SEA proposed by Goodland (SEA) and Buckley (SEA).

Since the Army is increasingly involved in "operations other than war" (OOTW), these issues are important. Regard for the host country environment, the health of the populations, and their sustainability will be an important part of the process of security stabilization. The history of the Army supports the concept of a "peacetime" Army with the ability to meet such challenges. Army commitments to mitigations must be illustrated through such mechanisms as those presented by Dlugosz and Scott in their discussions of the ECAS evolution toward a tool to measure organizational performance.

Implications for the Army Environmental Professional

The NEPA report card presented by Caldwell sends a message. While this may be above average for legislation, it does not bode well for NEPA's future. The CEQ evaluation supports NEPA's tenure, but many still view it as a "necessary evil." NEPA must establish a relationship between the NEPA practitioner and the decision-makers which NEPA should support. This "customer focus" is necessary if the TA experience (Roper and Porter; Holger-Strohmann) is to be avoided. The days of the "secular priesthood" are past; and the shift in emphasis from the "supply" to the "demand" side of NEPA analysis is required. While the technologists have historically driven the development of NEPA tools, it is clear that decision and policy makers will make decisions and formulate policy—with or without the input from the NEPA analyst. A 100 % solution after a decision is reached (or a policy formulated) is of no value, while a 75 % solution early in the process may prove invaluable. Roper and Porter characterize the TA experience, and, by analogy, the solution lies in an alliance with the decision- and policy-makers in which (1) the technologists and analysts agree to provide timely information and (2) the decision- or policy-maker agrees to use the information in the process.

NEPA Toolbox–An Army Approach

Canter discusses the use of NEPA analysis and documentation tools over the last twenty-five years and accurately summarizes their evolution from simple checklists at the beginning to the current emerging acceptance of tools which are "integrated" in a spatial analysis framework (e.g., GIS). This essay and Canter's previous work establishes the state-of-the-art in tools (methods, models, databases, etc.) and could provide the impetus for a review of methods and tools that would be best suited for the Army. There are a number of other technical sources (some unique to the Army) that could evolve into a toolbox that is specific to Army actions. Such a toolbox could simplify the Army NEPA process, constituting a "standard" approach to NEPA requirements, thereby bringing more discipline (technical and economic) to the entire process. This could complement current policy and guidance initiatives undertaken by the Army to improve the same process.

João presents the concept of tool integration through the use of GIS technology, an approach that has proven useful at all stages of the EIA process. Initial GIS implementation can be limited if tight project time frames and monetary constraints exist. However, the establishment of a GIS for the long-term can prove valuable, especially for land management agencies with a fixed geographic location and multiple projects. While further integration with other tools (GPS, internet, visualization tools, remote sensing, etc.) can enhance the value of GIS, many practical limitations still remain: implementation timelines and costs, availability of data, general unfamiliarity with GIS, and the opportunity to introduce errors in the analysis are but a few. Army experience confirms many of João's observations.

A NEPA toolbox would require the use of a GIS incorporating the broad and extensive Army data for each installation, addressing, in some manner, the baseline data issues discussed by Buckley, Buckley and Warnken, and Meier. The tool could also incorporate some of the characteristics discussed by the other authors:

- sustainability analysis (Goodland, Environmental Sustainability)
- policy level EIA (Bailey and Renton)
- monitoring of impacts; experience in the use of ecological indicators; knowledge of cause-effect relationships and subsequent use of models at a regional or ecosystem scale; better tools to account for the spatial heterogeneity of data at larger scales; development of theory and data to account for the effects of spatial heterogeneity; understanding of the errors associated with necessary data aggregation, the use of remote sensing, and the use of such tools as GIS (Hunsaker)
- the use of technology to efficiently and effectively address impacts; incorporating ease of use and efficiency, flexibility, consistency and comparability, replicatability; and dealing with the availability of data, simplicity of the model, and determination of the significance of model output (Webster)
- support of the decision-maker through decision-scoping, integrating the information stream and the requirements stream (Brown (Decision-Scoping))
- adherence to the principles of ecological management (Keiter and Adler)
- combined ecological and human health risk assessment (Gabocy and Ross)
- the use of scoping (public participation) to both establish context and link social considerations to related biophysical considerations (Taylor, Goodrich, and Bryan; and Goodman)
- the use of preliminary screening tools in conjunction with detailed analysis tools (Webster and Zoller)

- the valuation of economic “cost drivers” for life cycle system analyses (Taff and Leitch)
- incorporation of emerging environmental justice issues (Wilkinson)
- selection of appropriate models validated through independent peer review, fully documented, and available to the public while exploiting the trade-off between the use of simple models and their inherent compromising assumptions (Meier)
- integration of health risk assessment (Shinn).

The challenge to the Army will revolve around developing tools and processes that can yield efficiency and cost effectiveness in (1) project monitoring, (2) data analysis to derive appropriate information, and (3) policy and procedures modification to effect process improvement.

3

Ex-Post Evaluation of the Effectiveness of Environmental Assessment[1]

Barry Sadler[2]

Abstract

Environmental assessment (EA) has been institutionalized worldwide by governments and international organizations as a key mechanism for development planning and decision making. This paper provides a brief review of approaches and methods for expost evaluation of the overall effectiveness of the EA process and describes recent examples of their application. Also discussed are the contributions of effectiveness review to building quality control and assurance throughout the EA process and some promising avenues for further research and development in this area.

Key Words: audit and evaluation, effectiveness of assessment, overall and operational performance, value for decision making, ingredients of success

Background

The world wide adoption of EA, driven in part by the sustainability agenda, has brought changing perspectives on what constitutes good practice and effective performance. Critical analysis of how well EA works is a pervasive, recurring theme in the literature of the field, present in one form or another in most contributions. "State of the art" reviews are a well established means of surveying progress in EA and related fields (see Vanclay and Bronstein 1995), of taking stock of the institutional arrangements and procedures that are in force in particular countries and regions (see Wood 1995) and of examining the methods and techniques used for impact analysis and mitigation (see Canter 1995). Recently, increasing attention has been given to developing systematic approaches for ex-post review of the effectiveness of EA, focusing on the overall contribution to decision making and the quality of practice at key stages in the EA process.

This paper gives a brief introduction to instruments and strategies for reviewing EA effectiveness. It concentrates on the frameworks, concepts, and methods that can be used or are potentially available to evaluate overall and operational performance of the EA process. Research and development of this area is still at a relatively early stage. The following overview incorporates the results of a two-year international study of EA effectiveness (Sadler 1996), as well as insights from other research projects. A list of relevant materials and sources of information is included.

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[1]In this paper, the terms environmental assessment (EA) and environmental impact assessment (EIA) are used interchangeably as per international custom. The term EA is used generically, except where EIA refers to a process as officially designated (e.g., Netherlands EIA procedure). Both EA and EIA are understood to include related fields of impact assessment such as social impact assessment (SIA).

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Overview and Delineation of the Field

Ex-post evaluation here refers to a generic process of review, analysis, and policy-institutional interpretation of all aspects of EA effectiveness, encompassing the process as a whole and its components, methods, procedures, activities, products, and results. The term *effectiveness*, simply put, means whether these elements work satisfactorily to meet their intended purpose. As such, effectiveness is a broad, aggregate yardstick for judging performance. It encompasses related, subsidiary concepts such as *efficiency* (achieving the maximum outcome at the least cost) and *equity* (promoting fair access to or distribution of opportunities). These concepts (the three) underpin and structure policy audit, program evaluation, and other forms of effectiveness review to determine whether government activities realize their objectives and, in some cases, to question whether these objectives are appropriate (for further discussion, see *Impact Assessment Bulletin*, 7: 2-3, 1989).

In the case of EA, its effectiveness is often questioned by academic specialists, doubted by those who are required to comply with the process and undervalued by decision-makers and others who use the results. The EA process is recognized by many leading administrators and practitioners as falling short of realizing its full potential as a mechanism for informed decision making in support of sustainable development (see *International Summit on Environmental Assessment* 1994). Five major problem areas are identified in the critical literature as contributory factors to or constraints on sound practice and performance (Sadler 1995; Ortolano and Sheppard 1995):

- attitudinal—proponents and development agencies resist or circumvent EA or apply it as a pro-formal or narrowly technical exercise.
- structural—EA is not sufficiently integrated with decision making, notably at the project preparation phase or with other supporting policy, planning, and regulatory processes.
- institutional—the scope of EA is too narrowly defined or applied, such that social, health factors, and cumulative effects are inadequately covered.
- procedural—there is inadequate guidance and inconsistent enforcement of the EA process leading to "user" complaints about fairness, timeliness, and efficiency .
- technical—the quality of EISs, the accuracy of impact predictions, and the suitability of mitigation measures are often highly variable, even in relatively mature, advanced EA systems.

By contrast to general critiques of EA effectiveness, there is a limited specialized literature on the design and application of formal performance measures and evaluation methodologies. In addition, continuity in research appears to be lacking, component areas of study are insufficiently cross-referenced, and there is no widely argued framework for effectiveness review. Current interest in this area stems from a wider concern with strengthening quality control and assurance procedures throughout the EA process and particularly in the post-approval phase. Depending on aims, scope, and timing, effectiveness reviews can serve *development control* and *process development* functions, and, typically, will incorporate and evaluate information from project surveillance, field inspection compliance, and effects monitoring, environmental auditing and other follow-up activities. In many cases, however, these mechanisms are themselves incompletely developed and applied.

Types of Effectiveness Review

Six overlapping types or categories of effectiveness review can be identified in the EA literature:

Auditing and reporting for EA systems

Major reviews of the effectiveness of NEPA have been undertaken periodically (e.g., Caldwell 1982). In addition, the Council on Environmental Quality (CEQ) prepares an annual report, pursuant to Section 201, which includes an overview of trends in process application, for example number and type of EISs filed (CEQ 1995). Other countries, including the Netherlands, also have comparable annual reporting and/or periodic review requirements (e.g., Netherlands EIA Commission 1993; Netherlands Evaluation Committee 1990). The New Zealand Parliamentary Commission also exercises broad powers to "investigate the effectiveness of environmental planning," as well as to conduct ex ante reviews of EA (see Hughes 1996). In Australia, the National Audit Office (1993) undertook an efficiency audit of the Commonwealth EIA process, leading to current proposals for system reform (Australia Environment Protection Agency 1995). At the state level, Western Australia undertakes regular efficiency and compliance audits of the cost and timeliness of the EA process and is looking to establish broader scope effectiveness reviews (Sippe 1994).

Implementation Review and Follow up Studies

Recently, the World Bank completed its second three-year review of the effectiveness of its EA process which is widely applied in developing countries. The Commission of European Communities (1993) documented experience of member states in implementing the EIA Directive (85/337/EEC) over a five-year time period (1988-1993). The review covered both the transposition of the Directive into national law and regulations and the extent to which project planning, design, and authorizations were influenced by the EIA process. In the Netherlands, ex-post evaluation of the environmental effects of activities that have undergone assessment is a legal requirement and reports are made public by the competent authority. The Dutch Commission for EIA (1994) has prepared useful compilations of case experience. Process-specific follow-up studies of public reviews are undertaken as a matter of practice by the Canadian Environmental Assessment Agency. These also include independent monitoring of the effectiveness of large path-breaking inquiries such as the Beaufort Sea review (e.g., Sadler 1990) and Secretariat reports on the application of third party mediation as part of the assessment process (e.g., Mathers 1995).

Effects Monitoring and Impact Auditing

Audit and evaluation of the forecasts and predictions made in EISs and equivalent reports are a recognized means of improving the utility of methods and procedures for impact analysis and mitigation (Culhane, Friesema, and Beecher 1987). Early work in the United States, beginning in the 1970s, was followed by state of the art reviews of Canadian and international experience (Munro, Bryant, and Matte-Baker 1986; Sadler 1987). There is also a comparable body of work in Australia (e.g., Buckley 1989; Bailey, Hobbes, and Saunders 1992). Recently, Guidelines for Environmental Monitoring and Audit, issued by Environment Canada (Davies and Sadler 1990) have been adopted by the Hong Kong Environmental Protection Department (1995) for application to the Chek Lap Kok Airport (see also Au and Sanvicens 1996). For smaller scale projects and where conditions for baseline monitoring cannot be met, an "impacts backwards" approach to verify predictions and spot-checks for problems has been successfully used by the U.S. Environmental Protection Agency Region 6 (Lee Wilson and Associates 1993). In other contexts, impact audits are a specialized form of more comprehensive environmental audits of the type increasingly requested by the World Bank as part of its overall EA process (Lund and Kjorven 1995; see also Buckley in this volume).

Review of EIS Quality

Formal requirements for reviewing the adequacy and sufficiency of EIS and equivalent reports *prior to* their submission to decision-makers are well established in many countries (see Scholten 1996). Typically however, these ex ante evaluation procedures vary, guidelines and criteria tend to be ad hoc, and review practice is variable even among, for example, Canadian EA panels (Ross 1987; Sadler 1990). Recently, attempts have been made to develop and test systematic approaches for reviewing EIS quality based on standard criteria and rating systems (e.g., Lee and Colley 1991; European Commission 1994). This approach also has an ex-post application. Using an evaluation checklist of approximately 100 questions and consultation with key participants, van de Gronden, van Haeren, and Roos (1994) retrospectively graded fifty Dutch EISs as being satisfactory or unsatisfactory. The results were used to identify requirements for compiling a good, quality document. In the U.K., a government-sponsored research project incorporated three different rating systems to identify the changes that had taken place in the quality of environmental statements for planning projects since a previous survey was completed in 1991 (Glasson et al. 1995).

Decision-centered Analysis

A litmus test of EA effectiveness is the extent to which the process facilitates sound, informed decision making. This relationship is complex and difficult to evaluate because of the large number of intervening factors. However, recent studies have illustrated and exemplified the role of EA in modifying proposals, in setting terms and conditions for approval, and in influencing broader policy and actions. These respective dimensions are referred to as *visible, apparent*, and *perceived* effectiveness by van de Gronden, Beentjes, and van der Woude (1994). Building on this definition, the second (five-year) review of Dutch EIA experience, using a sample of 100 cases, found that the process resulted in environmental modifications to approximately 50% of all proposals, and that two-thirds were considered to have influenced the parties responsible for decision making. This analysis used a conservative methodology (requiring wide corroboration by parties consulted) and so the aggregate performance of EA is possibly underestimated. Similar findings are reported for the U.K. regarding the concrete (or visible) effect of EA on proposals, although the large majority of modifications were classed as minor or moderate rather than major (see Lee, Walsh, and Reeder 1994). The International Study of EA effectiveness utilized self-administered country status reports to gain an overall profile of the use of EA in decision making and compiled a portfolio of case studies of the scope of contributions to informed choice and the realization of environmental benefits (Sadler 1996).

Post-project Analysis

This approach connotes a comprehensive, long term hindsight review of major development proposals that have undergone assessment, received approval and are under construction, recently completed, fully operational or about to be decommissioned. As such, post-project analysis differs from other types of effectiveness review with regard to aim, scope and timing. In principle, post-project analysis provides a capstone to an interactive, “whole life cycle” approach to assessment and review, from proposal to disposal. In practice, very few examples can be found of such a total approach (Shell’s Brent Spar North Sea drilling platform is a possible candidate). Most post-project analyses to date are broader, single-focus implementation and follow up studies (UN Economic Commission for Europe 1990; Sadler 1987). The focus is primarily directed at future process improvements (rather than immediate development controls), and encompass technical, administrative and procedural aspects of project planning and EA.

Post-project analysis and other forms of ex-post evaluation can also be subject to meta-analysis to bring together EA case experience and the state of knowledge regarding types of impacts. Recent examples include effectiveness reviews of EIA procedures and methodology in the Nordic countries (Hilden and Laitinen 1995), and retrospective assessment of the social impact of resource based megaprojects in Canada (Boothroyd et al. 1995).

Recent Developments Toward a Comprehensive Approach

Recently, EA has reached a number of milestones (e.g., twenty-five years of NEPA experience, the tenth anniversary of the European Commission EIA Directive). Other events have brought new requirements and added challenges to the design and application of EA processes (e.g., Espoo Convention on EIA in a Transboundary Context, UN Conventions on Biological Diversity and Climate Change). In response to these developments, EA administrators and practitioners are giving increasing attention to process effectiveness and the frameworks and methods available for its review. Examples include the multi-country international study of the effectiveness of environmental effectiveness (Sadler 1996) and the parallel U.S. review of the effectiveness of NEPA (CEQ 1996). The results of the former study were also incorporated into the UNEP guide to EIA good practice (Scott Wilson 1996) and a companion EIA resource training manual (Ridgway et al. 1996) and are further extended by the International Association for Impact Assessment (IAIA) '96 *Conference Proceedings* (Partidario 1996).

The basis for a broad, comprehensive approach to EA effectiveness is now available. The context for such an analysis would be either reference to the specific institutional arrangements established by a particular country or comparison with widely agreed international standards of good practice. The framework outlined below can be applied to evaluate an EA process in its entirety. It comprises a package of concepts, principles, measures, and modes of evaluating both overall effectiveness of EA and the operational components that contribute to or constrain successful performance. Further details of the proposed approach can be found in Sadler (1996). Other useful information and perspectives on effectiveness review are contained in Ortolano (1993), Lee, Walsh, and Reeder (1994), and Wood (1995).

Organizing Concepts

A comprehensive approach to effectiveness review can be built on a "triangulation test" that interrelates policy, practice, and performance (The Three *P*s). Policy specifies what is required; practice is what actually happens; and performance is concerned with results—that is, whether what happened corresponds to what is required. EA theorists likely will not want to take policy as given and will prefer to review effectiveness from a normative standpoint of what ought to be done. In that case, the relevant paradigm should be identified explicitly, recognizing that there are conceptual differences between rational-scientific, socio-political and policy-organizational perspectives on EA and that in practice these approaches are variously combined in different "assessment cultures."

An evaluation of policy-practice-performance linkages can be undertaken along one or all of three main dimensions:

- procedural—does the EA process comply with established provisions and principles?
- substantive—does the EA meet its purpose(s) and objectives; e.g., support well informed decision making and achieve environmental protection?
- transactive—does the EA process deliver these outcomes efficiently (at least cost and with minimum delay) and equitably (without bias or prejudice to the participants)?

Applications to Practice

Several approaches to EA effectiveness review can be followed. These include:

- macro or system-wide review; e.g., one that examines procedural compliance and/or the contribution to decision making and other benefits gained from the use of EA for a given period of time
- micro or process-specific review; e.g., one that focuses on particular proposals or classes of activity subject to EA, from initiation to completion of the process
- meso-scale review; e.g., one that analyses intermediate aspects of EA performance, such as screening or scoping practice or the use of SIA methodology.

For well established EA systems, Doyle's (1994) rule of thumb regarding the Ontario process exemplifies the importance of taking a problem focused approach. Of 3000 proposals received each year, 300 proposals undergo preliminary assessment with little or no problem; thirty proposals require a full EA and demand a moderate level of attention; and three proposals are referred to public hearings, consume much of the time and effort of EA practitioners, and gain significant public and political attention. In this case, a process-specific focus can repay dividends of improved performance. In other cases, court rulings, user criticism, and public concern may indicate problems that are more widespread and point to the need for systemic review—as with the former federal Environmental Assessment and Review Process in Canada in the early 1990s.

Evaluation Principles

The purpose of EA effectiveness review is problem-solving, not finding fault. It is concerned with highlighting options and means for improving the quality of the EA process and practice. Seven principles can help to elaborate this proposed approach:

- take a systematic approach, placing EA in the overall context of the decision-making process and the forces and factors bearing on practice and performance.
- specify performance criteria, measures, and indicators for evaluating the overall effectiveness of EA and its operational characteristics (see below).
- adopt a multiple-perspective approach, canvassing views of participants to gain a full appreciation of process effectiveness.
- recognize that participant judgments of success are relative and vary with role, affiliation, values and past experience.
- as far as possible, corroborate and cross-reference these views with data and information from project files, inspection reports, effects monitoring and environmental auditing.
- qualify the issues and challenges by comparison to accepted standards of good practice (e.g., complex problem relatively poorly/well handled in the circumstances).
- when drawing conclusions, focus on the "art of the possible," contrasting what was accomplished with what could be achieved realistically.
- identify cost effective improvements that can be implemented immediately, as well as longer term, structural changes that appear necessary (e.g., to law, procedure, and methods).

Performance Criteria, Measures, and Indicators

Attributes of effectiveness have been proposed for national EA systems; e.g., for Canada (Gibson 1993; Doyle and Sadler 1996) and for international application based on accepted principles and standards of good practice (Wood 1995; Sadler 1996). For present purposes, seven generic yardsticks can be applied to screen the macro-level performance of EA systems. Specifically, does the process have:

- *a well founded legislative base* with clear purpose, specific requirements, and prescribed responsibilities?

- *appropriate procedural controls* to ensure the level of assessment, scope of consideration and timetables for completion that are relevant to the circumstances?
- *incentive for public involvement* with structured opportunities tailored to the issues and interests at stake?
- *an explicit problem and decision focus* concerned with the issues that matter, the provision of credible, consequential information, and explicit linkage to approvals and condition setting?
- *a follow-up and feedback capability,* including compliance and effects monitoring, impact management, and audit and evaluation?
- *a sustainability-orientation* towards promoting environmentally-sound development; i.e., within the assimilative and regenerative capacity of natural systems.

The litmus test of the overall performance of the EA process at both the macro and micro levels is relevance for decision making, broadly considered to include all stages of project (and policy) review not only confined to formal approval and condition setting. A key distinction is between:

- *the quality of the information products* delivered by EA—e.g., was the final report timely, relevant, and focused on the issues?
- *the degree of influence of EA* on the choices made—e.g., did the terms and conditions take into account the information supplied and advice given? And, equally important, was a balanced decision reached in which environmental, economic, and social considerations were appropriately weighted, given the circumstances?

In both cases, EA practitioners are interested also in the operational conditions that contribute to or enable successful performance. The degree of influence that EA has in decision making depends on a number of factors, including political will and the play of events that circumscribe its exercise. The quality of the information provided by assessments can be linked directly to the integrity of the process. Effectiveness will reflect the interaction of two interrelated components of an EA system:

- *appropriate institutional controls* that provide formal structure and direction to assessment as outlined above; and
- *adequate operational competence in The Three* R*s of EA practice* applied at each stage of the process as shown in Figure 3.3. The Three *R*s of good practice comprise (Sadler 1990):
- rigorous analysis—application of “best practicable” science to the nature and scope of the issues and impacts
- responsive consultation—the “appropriate” use of techniques and procedures; i.e., for the issues and in relation to the affected communities
- responsible administration—timely, consistent, and adaptive implementation of provisions and principles, without bias or favor to or against parties

Ultimately, the effectiveness of EA is measured by the extent to which the process meets its substantive objectives. These focus on the delivery of environmental protection and other benefits as indicated by the reduction, avoidance, and mitigation of adverse impacts, that is, consistent with air and water quality standards, ecological guidelines, etc. Wherever possible, also take account of other direct and indirect policy benefits that are attributable to the EA process. Finally, give a cost estimate and evaluate whether the environmental benefits were delivered efficiently (although the methodologies for this purpose remain unsatisfactory).

Qualifications

With few exceptions, evaluations of performance and judgments about success will be subjective and subject to the following qualifications:

- the EA process operates in an open-ended, decision-making context
- it is taken forward and influenced by the actions of numerous participants
- the outcomes of the process are not always clear or apparent
- as a result, cause-effect relations cannot be measured or quantified
- the evidence on which judgments are based will be circumstantial.

Recommendations

Systematic approaches to ex-post evaluation of EA practice and performance are still at a relatively early, formative stage of development and application. Many methodological issues related to measurement and interpretation remain to be resolved. An integrated framework for effectiveness review, incorporating the evaluation concepts and criteria described in the previous section, remains to be substantiated and rigorously tested by case applications at different scales and contexts. But such an approach can provide a disciplined perspective on and means for strengthening the EA process as a whole and with respect to particular operational components that require attention.

Above all, there is an evident requirement to use effectiveness reviews as an integral strategy for building quality control and assurance throughout the EA process. Without this type of careful, retrospective analysis of what works well (and what does not), EA will continue to operate as a relatively open-ended process, lacking the basis for control, feedback, and continuous learning. In this regard, priority areas for research and development include:

- sharpening formal methodologies for effectiveness review
- documenting the contribution that EA makes to key stages of the decision-making process
- examining further the ingredients of success, including setting terms of reference, examination of alternatives, and use of appropriate analytical and mitigation methods
- strengthening monitoring, audit, and other follow-up opportunities that are critical for providing information for effectiveness review.

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4

Improving the Quality of Environmental Impact Statements (EISs)

Ralf Buckley[1]

Abstract

Environmental Impact Assessment (EIA) has matured somewhat over the past two and a half decades, but it still has many shortcomings, some technical, and some political and institutional. Some of the issues which need resolution before the technical quality of EIA is likely to improve include: funding for various components and inputs; selection, evaluation, training and accreditation of consultants; mechanisms for effective public participation; mechanisms for effective review of EIA documents; and mechanisms for cumulative and strategic EIA. Triggering mechanisms, mitigation, and monitoring are as important as the technical quality of EIA, but their value is greatly reduced if core EIA is of poor quality. Technical quality in EIA is a necessary but not sufficient condition for an effective EIA process.

Key Words: quality EISs, EIA, quality, funding, standards, consultation, review, assessment, monitoring

Background

This review attempts to list some of the main issues in improving the quality of EIA documents from the time when formal EIA is triggered to the time when a set of EIA documents is considered by a decision-making body. It does not examine the processes which trigger EIA (Buckley 1992) or determine its scale and scope. Nor does it consider post-development audit and monitoring, (Buckley 1991a, b, c, 1995) or frameworks for legal challenge (Buckley 1991d) and other conflict resolution approaches (Buckley 1991e). It focuses specifically on:

- funding for and actual preparation of EIA documents
- raising professional standards in EIA
- consultation during EIA
- reviewing EIA documents.

Formal EIA documents produced by or on behalf of project proponents will be referred to throughout as Environmental Impact Statements, EISs. The actual terms used differ between countries and jurisdictions.

If an EIS is technically competent, containing accurate and adequate baseline descriptions, impact predictions, and details of mitigation, management and monitoring programs, then it should be able to withstand scrutiny by any number of assessors, government or otherwise. So the technical competence of EISs is an issue important to all aspects of the EIA process.

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Funding EIA

Cost Components in Single-Project EIA

The issue of funding for three various components of EIA is important not only for social equity, but also because without adequate funding the quality of particular components is likely to be poor. For traditional single-project EIA where the scope, scale and timing of the EIS have been defined:

- The costs of preparing the EIS are currently borne by the proponent.
- The costs of involvement in the EIA process by people directly affected by the proposal are currently borne by the individuals concerned.
- The costs of involvement by third parties, such as environmental non-government organizations or community legal services, are currently borne by those parties or sometimes by government grants or aid.
- The costs of mounting public hearings and consultation are generally borne by the proponent, or occasionally by government agencies.
- The costs of legal challenges and interveners are currently subject to court orders at the outcome of court proceedings.
- The costs of government assessment of EIS are currently borne by the taxpayer.

Funding Public Input to EIA

A mechanism is needed to ensure funding for public responses to the EIS—e.g., for community groups to commission expert reviews. Funds could be provided by government in the form of grants, but these are then contingent on short-term government spending priorities. Alternatively, they could be provided through a levy on proponents. A hybrid mechanism might also be possible, with a public trust fund replenished by a scaled levy on proponents once projects are granted development approval.

Funding Other Forms of EIA

Currently, less traditional forms of EIA, such as regional or local environmental planning; cumulative, strategic and policy environmental assessment; and alternative dispute resolution techniques are publicly funded in most jurisdictions, except in Alternative Dispute Resolution (ADR) where each party generally bears its own costs.

Preparing EISs

Who Prepares EISs

The quality of EISs depends heavily on who actually does the technical work of compiling the EIS and supporting documents; including everything from baseline studies through to printing and distribution. In particular, there has been considerable debate over the objectivity of EISs in relation to the independence of consultants (Buckley 1989a, 1990, 1991f). Currently there are four different systems in operation for different types of EIA in different jurisdictions. The first is by far the most common:

- consultant hired by proponent
- consultant hired by government
- consultant hired by proponent from government register
- consultant selected by government but paid by proponent.

Evaluating Technical Competence

The technical competence of EIA may be assessed in relation to many different parameters, including:

- scope and timing
- adequacy of baseline data, including sampling design etc.
- identification of major potential impacts

- adequate attempts at prediction for major impacts
- accuracy of predictions
- adequate definition of mitigation and management programs
- adequate definition of monitoring programs and data access.

For most of these there have still been relatively few attempts at systematic evaluation. Scoping systems are in common use, but have they been evaluated?

A recent analysis of the adequacy of baseline data in EIA for one particular sector, namely tourism in Australia (Warnken and Buckley 1995a, b, 1996, Buckley and Warnken this volume) found that for most EISs, baseline data are inadequate to detect impacts and hence determine when management action is required.

An evaluation of twenty-three projects in the mining sector in Australia selected jointly by representatives of the mineral industry and environmental NGOs (Buckley 1991g) found that many impacts which actually occurred had not been predicted. There have been several evaluations of the accuracy of environmental impact predictions (Buckley 1989b, 1991a, b, 1995); inaccurate predictions are commonplace.

Details of mitigation, management and monitoring programs, in Australian EISs at least, are still very sketchy (Warnken and Buckley 1995a). Indeed, for some jurisdictions and projects, there has been a recent tendency to defer such components to poorly defined "Environmental Management Plans" (EMPs) which are not compiled until after the project concerned has received approval (Buckley 1994a). Clearly, there is very considerable scope for improving the technical competence of EIA.

Raising Professional Standards in EIA

Incentives

The first issue in raising professional standards is that of incentives: how to make individual EIA practitioners want to improve their own professional competence. There seem to be five possible mechanisms.

One possibility is short-term market forces. If EIA practitioners who wrote better EISs were paid more or hired more often, there would be an incentive for individuals to improve. Currently, however, this is not generally the case. For the community at large, a good EIS is one which provides more accurate information and predictions on which to base judgments; but for the proponent who hires the consultant, a good EIS is one which gets the project approved quickly with minimum cost and forward commitment. Hence better EIA professionals, from a public standpoint, will only earn more from the private sector if public processes for assessing EISs are stringent.

Potentially, an incentive to improve might also be provided through public critique of EIA documents. Since individual EIA professionals or even EIA consulting firms are rarely in the public eye, however, unless legal challenges to particular development proposals receive major media coverage, public critique is unlikely to provide an effective incentive.

In some jurisdictions, government-influenced market forces may be significant. Government processes, such as registration or accreditation, may influence hiring decisions by the private sector, so that professional income depends indirectly on reaching the professional standard required for accreditation.

Longer-term market forces, in the form of competition for employment and promotion within the private sector, might also provide an incentive; but I don't know of any data which relate salary, seniority of appointment or rate of promotion specifically to technical competence as compared to, e.g., marketing skills, corporate management skills or indeed simply length of employment.

Finally, peer pressure and recognition within the profession, whether informal or through professional accreditation, may also provide an incentive to improve. Aspects may include professional integrity, i.e., loyalty to competent professional practice before loyalty to an employer (as compared to doctors, engineers); the ability to engage in technical criticism of work by others within the same profession; and professional awards in recognition of high performance.

Training and Self-Evaluation

The second major issue is the quality, accessibility, and affordability of training available to individual EIA practitioners who want to improve their professional standards. Currently, the main avenues to obtain information in order to maintain or improve competence include:

- journals, books, newsletters, EIA reviews, reports
- conferences, professional update services, executive short courses
- information services on disk, CD-ROM or the World Wide Web
- professional associations and networks such as IAIA.

All of these, however, rely on using the expertise of others secondhand. Who trains the trainers? Ideally, EIA practitioners should evaluate their own abilities continually by tracking the accuracy of their own impact predictions. This can only be achieved by following up the results of environmental monitoring on projects for which they made impact predictions, even if such monitoring was performed by others. This is far from straightforward, however, for three main reasons.

Many projects are modified considerably between EIS and construction, and many monitoring programs do not measure the parameters for which impacts were predicted, or not at the same locations or frequencies, so testing the accuracy of impact predictions is often technically difficult (Buckley 1989b, 1991a, b, 1995). Many projects are delayed for many years before proceeding, and the individuals who made the impact predictions may no longer be able to obtain information from the project. Monitoring results may not be made publicly available. And commercial pressures on individual consultants do not provide them with time or funds to conduct analyses for their own benefit rather than those of commercial clients.

External Evaluation

One way to overcome such difficulties would be for routine audits of the accuracy of impact predictions in EISs to be carried out by independent agencies, either by government or by consultants commissioned by syndicates or professional associations of EIA practitioners. To date some such audits have examined the relative accuracy of different types of predictions, but have not compared predictions by different individuals. Indeed, few EISs identify the individuals who made each prediction.

Besides, accuracy of predictions is only one measure of competence in EIA: it depends on many other factors as well as the skills of the individual practitioner (Buckley 1989a, 1990, 1991c). An alternative approach, therefore, might be for assessment agencies to publish annual rankings for the professional standards of all the EISs they have assessed that year, or a cumulative ranking for several preceding years. Alternatively or additionally, assessment agencies could publish critiques of professional standards of EIA documents, as well as assessments of the likely impacts of the projects concerned. Of course, this would require assessment agencies to provide additional time and resources at taxpayers’ expense. But the public does want to know how good or bad particular EISs are, and this requires not just a public register of EISs but some kind of published review or critique.

Accreditation

The third major issue is accreditation: how can we tell what relative professional standard an individual has reached? There are at least five different forms of accreditation system which are or could be used for EIA practitioners in different jurisdictions:

- government accreditation schemes, as for environmental auditors in one Australian state
- privately run third-party schemes, as for some retail goods; in EIA, these include schemes run or recognized by insurance companies or associations
- legally-recognized professional schemes, i.e., accreditation systems run by the profession but required by government for permission to practice; as for doctors, teachers, and lawyers in most countries
- government-endorsed professional schemes, run by the profession and accepted by government as evidence of competence, though not legally required in order to practice; as for accountants in many countries
- privately operated schemes based on national or international standards, run by private operators who have to be accredited themselves in order to accredit others; as for the BS7750 and ISO 9000 and 14000 series for environmental audit and management systems, and the NATA (National Association of Testing Authorities) proposals for EIA accreditation in Australia in the 1980s, which were never put into practice.

For all such systems, accreditation may be either by peer review or professional examination. If the former, there is a risk that the scheme may effectively define only procedural rather than substantive requirements.

Consultation

Level of Consultation

EIA frameworks in many jurisdictions make some reference to public involvement, but the degree of involvement in practice varies greatly (Ortolano and Shepherd 1995, Roberts 1995). Three different levels can usefully be distinguished (Buckley 1991c):

- *Information:* proponent or assessment agency tells the public what they want the public to know, or what they are required by law to reveal; advertising and access to such information may also differ widely.
- *Consultation*: proponent or assessment agency actively seeks information and opinion from the public, but does not necessarily act on it.
- *Participation*: public has formal input to decision-making processes; decision must reflect public opinion.

Currently, requirements to provide some public information and allow an opportunity for public response are common in EIA, but active consultation is relatively uncommon, and participation very rare. The closest approach, provided for in planning law in a few jurisdictions, is generally a statutory avenue for third-party actions if procedural requirements for EIA are flouted (Buckley 1991d).

Administrative appeals legislation provides a second, though substantially less accessible, mechanism in some jurisdictions. Rarely if ever, however, does EIA legislation contain substantive provisions linking development consent to public participation. Even in the State of New South Wales, Australia, for example, which specifically provides avenues for public challenge to development consents involving EIA, the Land & Environment Court has ruled that public concern alone is not sufficient to trigger procedural requirements for EIA, let alone substantive provisions in regard to development consent (Buckley 1991d).

Public Access to Government Information

For information about a proposed project, the public currently has to rely on the EIS, which is a proponent statement (Buckley 1989a, 1990, 1991c). The final goverment assessment is generally also made public in most jurisdictions, but not until after the public comment period is over. Various government agencies, however, typically prepare expert commentaries on the EIS either as submissions or by invitation of the lead environment agency, and it is not clear why these could not be made available to the public along with the EIS. Government reports may be available under Freedom of Information legislation in some jurisdictions, but this has four major disadvantages:

- the requester has to know the reports exist.
- it is often expensive.
- proponents can resist release of government information by invoking commercial confidentiality clauses.
- it is too late: the development decision has already been made.

Consultation Mechanisms

There are many different mechanisms for public consultation, and these draw very different levels of public response. If the proponent merely makes documents available at a limited number of locations for a limited period of time, then community groups and individual members of the public wanting to provide data or voice an opinion can only do so if they are already aware of the development proposal and following its progress closely. If, as is commonplace, the proponent or assessment agency is simply required to advertise the public comment period in a government gazette or local newspaper, it may be almost equally difficult to find the advertisement. If the proponent and assessment agency are actively seeking public input, they may circulate information to local community groups, national ENGOs, etc. Better still, they may have identified interested individuals and organizations and actively sought their input from the earliest phase of EIA. EIA consultants will sometimes canvass this option, but proponents differ greatly in their response.

In some jurisdictions there are requirements for public meetings, but these vary from useful avenues for public input to formalized exercises in crowd control. The factors differentiating these extremes include:

- the number of meetings held
- the stage in project development at which they are held
- the length of time allowed for further public input after the meetings
- who bears the costs of meetings
- who prepares the agendas
- who decides the place, time, and format of each
- whether meetings are open-ended or orchestrated, free-form or choreographed
- how much influence the meeting outcomes have on decision-making processes.

Public participation in meetings is also likely to be more committed and constructive for the proponent if it is linked to ongoing involvement in the development; e.g. through the establishment of environmental monitoring oversight committees with public representation. At one recent Australian workshop on federal-level EIA, for example, NGOs argued strongly that the appointment of such committees, which has occurred only very occasionally to date, should become routine. At the very least, monitoring data should be routinely available for public inspection in a timely manner and free of charge.

Also important in public consultation are:

- access to supporting documents: by whom, for how long, and at whose cost
- whether public review is one-shot or iterative, e.g. through PERs, drafts and supplements

- the legal administrative framework: how public comments influence approval decisions, operating and monitoring requirements, and the avenues available for challenge and appeal.

Reviewing the Document

Responsibility for Formal Assessment

The most critical issue in reviewing EIAs is who formally assesses them. The government, certainly, but how? For example, in a federated nation, are EISs assessed by local governments, by the state government of the state where the project is located, by the federal government, by other states, or by some combination? Generally, this depends on the jurisdiction and the type of development. Rarely, for example, are other state governments involved, even though they may have relevant expertise and direct interests.

Once the level of government has been determined, the next issue is which particular agencies are involved. Is it the environment portfolio, the portfolio for the industry sector concerned, other portfolios, or some combination? And if the environment agency performs the assessment, for example, does the environment minister have the right to refuse development approval, or only to advise the minister for the sector portfolio, the minister for industry development, the prime minister, or the cabinet? It can make a big difference to the outcome (Buckley 1991c, d, 1993).

Some assessment agencies make all their deliberations in-house. Others, notably Australia's Great Barrier Reef Marine Park Authority (GBRMPA), routinely hire individual experts or EIA consultants to assist in assessment. This so-called GBRMPA model has been widely commended by ENGOs as utilizing the best expertise available in the community at large rather than only in the agency concerned; or at a more cynical level, "setting a thief to catch a thief." ENGOs have also requested formal avenues for involvement in assessment, but this rarely happens except in a (very) few international bodies.

Stringent Assessment Yields Better EIA

There are *some* cases where the ability to describe baseline environments and predict and monitor impacts is limited by technical capabilities. In *most* cases, however, this technical limit is not reached, because consultants are constrained by the time and money proponents allocate to EIA. Proponents will only increase this allocation if they know that their EIS will undergo a stringent assessment process, such as a judicial or parliamentary Inquiries. Retrospective evaluations of EISs (Buckley 1989b) have also demonstrated that EISs from projects subject to such Inquiries contain far more testable impact predictions than those which are not.

Cumulative and Strategic EA

Cumulative and strategic environmental assessment (CEA, SEA) are important applications of EIA (Buckley 1994b, c, 1995, Goodland this volume, Hunsaker this volume). EIA of programs and policies is already carried out routinely in other countries, including New Zealand, the U.S., Canada, and Germany. Professional capabilities for CEA and SEA are well advanced (Buckley 1994d, Vanclay and Bronstein 1995). Barriers to their adoption and application in most jurisdictions are political, legal, and economic rather than technical (Buckley 1994b, c). Strategic environmental assessment conducted or commissioned by government agencies could commence immediately and routinely in most countries.

Cumulative environmental assessment may be considered in two main categories:

the marginal cumulative impacts of individual projects, and the aggregate cumulative impacts of regional development. The former can be included in single-project EIA simply by specifying a requirement in EIA guidelines or scoping. The latter is an aspect of regional planning and is generally carried out and funded by government agencies (Buckley 1986, 1994a). Regional planning approaches have been adopted to different degrees in different states in Australia, for example, either as state government initiatives or through consortia of local government authorities (LGAs).

One mechanism for national or federal governments to encourage regional environmental planning (REP), and CEA in particular, therefore, is by direct grants to LGAs in the region concerned, whether all in one state or in adjoining states. Where REP is conducted as a component of sectoral planning, either at state level or a smaller scale, it would generally be appropriate for the relevant sectoral agency to fund CEA. Where CEA is required because a number of individual proponents submit development applications (DAs) simultaneously in the same region, and the cumulative impacts if all were approved would be significant, then CEA could be funded initially by the LGAs concerned, and costs recouped by headworks charges or levies on the proponents whose applications were approved. This would have to be made clear to proponents when their DAs were first submitted to LGAs. It seems likely that issues of this type will become increasingly important and need urgent consideration in many countries.

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5

Progress of Environmental Impact Assessment and Its Methods in China

Li Wei, Wang Huadong, and Liu Dongxia[1]

Abstract

This paper introduces the recent evolution of Environmental Impact Assessment (EIA) methods in China, focusing mainly on the use of Regional Development Environmental Impact Assessment (RDEIA) and Social Environmental Impact Assessment (SEIA). Based on the proven achievement of EIA methods, as well as recent innovations in the field, we propose a new methodology of EIA termed "meta-synthesis" for use in China. Finally, we anticipate the future study and development of EIA trends.

Key Words: China, environmental impact assessment (EIA), regional development EIA, social environmental impact assessment, biodiversity impact assessment, strategic environmental assessment

Introduction

Great progress has been made in recent years on EIA, which is one of eight requirements for environmental management in China (Qiao Zhiqi 1994). This progress has been marked by a continual increase in the quantity of projected environmental impact assessments that have been completed, the extension of EIA's field, continued research work on EIA, the consummation of EIA methodology, enrichment of EIA's coverage, and diversification of EIA's objectives. In addition to regional and strategic EIA, which are characterized by broader coverage and a higher level, some new EIA methods have been established or are developing, such as the methods of environmental risk assessment (ERA), regional development EIA (RDEIA), social EIA (SEIA), and Strategic EIA, as well as a method for evaluating the effects on biodiversity.

Environmental Risk Assessment

Since the environmental risk posed by nuclear power stations was first evaluated in China (Shi Zhonqi 1983), environmental risk assessment (ERA) has been studied mainly in the following four fields:

Ecological Risk Assessment on Hazardous Chemicals

Many mathematical models have been used for assessing toxic risk on various ecological media (e.g., water, air, soil, flora and fauna) caused by leakage (Hu Defu 1991), explosion (Lu Qingwu 1990), diffusion (Liu Yufen 1989), movement and transformation of chemicals (Wang Huadong 1990; Dai Shugui 1991), and exposure to chemicals (He Xiquan 1990).

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ERA of Building Projects

This method of environmental risk assessment has been applied mainly to petroleum and natural gas pipelines, large-scale chemical plants, and nuclear power stations. The methods used for such assessment include fault tree/event tree analysis, Monte Carlo simulation, fuzzy risk degree and integrated risk index, and probability risk evaluation.

ERA of Large-Scale Hydroengineering

In an environmental risk assessment of the South to North Water Transfer Project, tier analysis and fuzzy probability/false tree analysis were used separately for risk identification and risk appraisal, and the integrated risk was calculated by using gray connection and an integrated risk index (Wang Fei. and Wang Huadong 1995).

Regional ERA and Regional Risk Management

Based on regional risk field theory, the transport risk of hazardous and toxic substances was evaluated by using transport models and health risk analysis. One of the main cases is the ERA of storage and transport of hazardous wastes in Shenyang, Liaoning province (Bi Jun 1994).

Regional Development Environmental Impact Assessment (RDEIA)

Now that China is experiencing rapid development, EIA must be done. However, it has been proven in practice that the prevailing project-based method of EIA alone cannot meet the requirement of controlling the total amount of pollutants and rational industrial location, and, furthermore, that it cannot deal effectively with the cumulative effects induced by interaction between projects (which are generally more than two) within an area. In order to address this shortcoming and meet the requirement for evaluating cumulative effects caused by large-scale development, regional development environmental impact assessment (RDEIA) was formally initiated in China at a seminar held by the Chinese Environmental Science Society in April of 1986 (Wang Huadong 1986). RDEIA attempts to predict and evaluate the possible environmental impact brought about by alternative development plans or programs within a certain region. Based on these findings, an optimal regional development plan is selected in compliance with the principles of environmental protection and sustainable regional development, therefore providing measures to reduce and mitigate negative environmental impact, especially cumulative effects over the region.

In practice, besides transplanting and continually using some conventional EIA methods, a few new methods specially for RDEIA have already been developed, in which a system engineering method of RDEIA proves a useful method in practice (Li Huiming and Yu Aimin 1986). This method regards RDEIA as a large-scale complicated multi-elemental system which can be roughly shown by a three-dimensional model (see Figure 1).

Figure 1 demonstrates that RDEIA system engineering activities are divided into seven interrelated temporal phases and seven logical steps, and that multiple techniques are applied simultaneously during evaluation. This method has been successfully applied in RDEIAs of areas such as Ma Anshan in Anhui province, the old industrial zone of Lanzhou in Gansu province, and Mei Zhouwan in Fujian province, among others. In order to comprehensively evaluate the broader environmental impact and make proper trade-offs among environmental, social, and economic effects during application, a valuable concept of “environmental carrying capacity” was introduced (Ye Wenhu 1992).

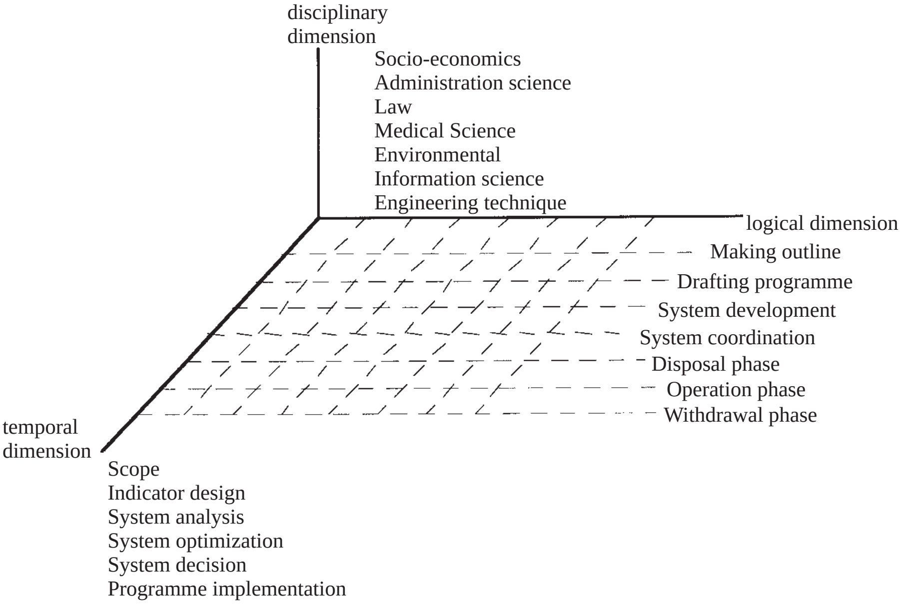


Figure 1. Structure Model for RDEIA

This concept refers to the largest threshold attributed to a certain target environment or target environmental element to support a specific human activity or activity group. For example, there are some development variables (e.g., various human activities) and restriction variables (e.g., various local environment and resource conditions) for a regional development. If said development variable is the intensity of human activity within a region, then let the restriction variable represent the state of the regional environment or environmental element. Thus the regional environmental carrying capacity is the maximum value of the regional development variable as it is limited by the regional restriction variable. At present, research related to this concept is conducted widely, and it is generally believed that this concept has the potential to become a criterion for assessing regional sustainable development. Though research on regional cumulative effect evaluation is in its developing stage, such evaluation requires multiple methods and stronger monitoring (Li Wei and Wang Huadong 1995b). The Chinese EPA is compiling an assessment outline for RDEIA.

In summarizing RDEIA, the following points should be considered:

- Total amount control of pollutants should be considered specially for the redevelopment of old development zones where a certain degree of pollution has already been reached.
- Environmental carrying capacity of new development zones should be carefully studied, and the results of such study should guide functional districting selection of the leading industry, and rational industrial location.
- The transitions and buffers between different functional districts should be taken into account.
- The cumulative effects caused by a regional development should be exhaustively analyzed and evaluated.

Social Environmental Impact Assessment (SEIA)

When a country experiences a period of rapid economic growth, a harmonious social environment is one desired outcome. However, in a country of China's size and population, it remains difficult to provide adequate food, clothing, and shelter for citizens living in impoverished areas. Therefore, social environmental impact assessment (SEIA) is necessary if China is to maintain overall sustainable development.

The SEIA of a poverty reduction project funded by the World Bank in Guangxi in southeastern China occasioned summarizing the existing methods for SEIA. It also led to a new integrated quantitative assessing method for SEIA—"tier-route model" (Wang Huijun 1995), as well as a corresponding system of assessing indicators. This method combines tier analysis and network analysis, in which "tier" refers to divided levels of social environment. The main level categories are listed in Table 1.

Table 1: Main Level Categories of Social Environment

First category	Second category	Third category	Fourth category
1. Natural environment, resource and ecology. 2. Economic environment, resource, and ecology. 3. Social environment, resource, and ecology.	1. Individuals 2. Households 3. Social group 4. Community 5. Regional society	1. Survival need 2. Interdependence need 3. Growth need	1. Social psychology 2. Cultural environment 3. Material environment

"Route" refers to the three ways of transmitting impact (see Figure 2). First is via material transfer. For example, toxic waste water discharged into a river by a chemical plant may affect the lives and health of residents miles downstream. The second way relates to structure. A high-tech project may promote the development of a high-income stratum and quickly change social positions in the local community, causing potential conflict among classes. Third is through communication of information. Labor export involved in a poverty reduction project may introduce new thoughts and ideas as well as changes in lifestyle through the laborers' family relationships and interaction with local society, thereby breaking the confining state of local society. All these methods of transmitting impact may interact within the social network.

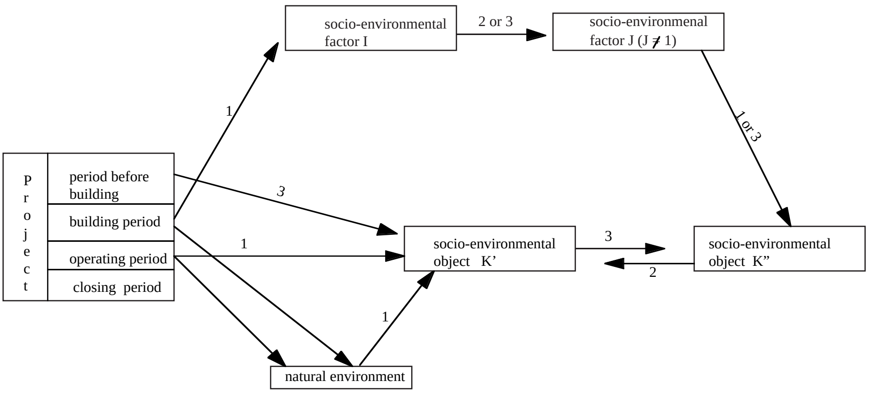
In order for this method to quantitatively evaluate social effects, it is necessary to compare, integrate, and calculate all affected indicators. However, the indicators have different units and varying scales, so one must first convert them into comparative indices.

Assume the upper limit of indicator 'A' is C_2 and the lower limit is C_1, if A=a', then the index value (a) of A may be expressed as

$$a = \frac{a' - c_1}{c_2 - c_1} \times 10 \qquad \text{..........................¨}$$

It can be seen from the expression that the index value of A will fall in the range [0,10]. If the index values of A are respectively a_1 and a_2 when there is a project and when there is not, then the effect can be defined as

$$\Delta a = a_2 - a_1 = 10 \times \frac{a_2 - a_1'}{c_2 - c_1} \qquad \text{..........................}\neq$$



1- material way; 2 - structure way; 3 - information way.

Figure 2. Transmitting Ways of Social Impacts

By combining the effects on all indicators with the affecting temporal index and affected social scale, the total impact (ΔX), which represents the algebraic sum of positive and negative effect, can be gained. If $\Delta X>0$, then the positive effect exceeds the negative one, and vice versa. In addition, if the absolute value of index amplitude is used in calculation, then the total impact scale (S) and the scale of positive impact are available, and the following relationship may be deduced:

$$S_N=S-S_P$$

Where S_N represents the scale of negative impact.

The evaluation on predicted results depends on the value of X and the relationship between S and S_N (or S_P), and a datum value of $S(S_O)$ may be given so as to indicate and compare the scales of impact. For the aforementioned poverty reduction project, given $S_O=3000$, the final conclusions are as follows:

(1) $\Delta X>>0$ indicates that the social environmental benefit of the project is positive and very large.
(2) $S>>3S_O=9000$ indicates that the scale of impact is of meta-scale.
(3) $S_N>>900$ shows that the negative impact is substantial and cannot be neglected.
(4) $S_P:S_N=11:1$ means that the positive benefit of the project is ten times more in value than its negative effect.

Biodiversity Impact Assessment (BIA)

China is a country rich in animal and plant life, many species of which are rare, but now it faces the dilemma of how to protect its natural environment without halting the progress of development. In order to comply with the International Convention on Biodiversity and to coordinate economic growth with protection of the environment, it is imperative for China to develop research on biodiversity impact assessment (BIA). Lately, a method, "fuzzy integrated assessment," has been advanced for evaluating the effects on biodiversity caused by projects. This method is based on a set of indicators and assessment criteria which use tier analysis to produce weights for the indicators, and provides basic data through professional scoring, using fuzzy integrated assessment to evaluate impacts. The final evaluation is then derived by comparing the effect on biodiversity with the effects on society and the economy produced by the project. At present, the method is used to evaluate the effect on biodiversity in the Yellow River delta by oil exploration and the effect of diverting water from the Hi River to Xian on the snub-nosed monkey and other species in the Taibai Mountain natural protected area.

Strategic Environmental Assessment (SEA)

Effective strategies and policies are essential for economic growth and environmental protection. It is a commonly held belief in China that ineffective public policies are contributing to environmental pollution and a deficient level of sustainable development. However, research on strategic environmental assessment (SEA) in China has just begun, and as yet there has been no generally acknowledged method for implementing it (Li Wei and Wang Huadong 1995a).

So far, there are only two related cases in China: one is the EIA on the strategy of applying equal emphasis on electricity and coal in Shanxi province (Li Zhen 1995); the other is the EIA on national legislation of hazardous chemicals pollution control which is conducted simultaneously with the lawmaking process (Li Wei 1996). In the first case, on the basis of having acquired access to a substantial amount of basic information, the author used cost-benefit analysis to analyze and evaluate the strategy, and provided the following recommendations:

- The strategy will not only bring more economic and social benefits to Shanxi province, it will also produce more air pollution. Thus, a part of economic benefit should be used for environmental protection, namely for controlling air pollution caused by burning coal.
- At least 7.4% of the annual electric power building investment should be allocated for treatment of SO_2 pollution.
- We need to continually improve techniques to reduce coal consumption for producing 1 kilowatt-hour electricity.
- Joint production of heating and electricity should be a basic requirement for all power plants.
- We should strengthen scientific research to develop practical desulphurization technology for thermal power plants.

In the second instance, social survey and public participation were used in the first phase EIA undertaken from August 1995 to January 1996. In this assessment, “the public” was classified into two categories, “special public” and “general public.” “Special public” refers to the officials in government departments, government consultants, people’s representatives, experts, and scholars. “General public” refers to average citizens. Furthermore, SEA is characterized by stages of public participation. Since national legislation is a complicated process, participation by members of the special public was therefore organized mainly at the preliminary stage (first phase). The participants included officials from twelve related national departments and research staffs from affiliated scientific institutes.

Conclusion

All introduced and discussed above is about the evolution of EIA and its methods in China, in which some methods have already been proven effective and reliable, and some other methods are being verified and studied further. At the same time, issues such as the use of cost-benefit analysis as a tool in EIA and the effectiveness of EIA in general are also being studied. Confronted with so many methods of EIA, as well as complex social and environmental impacts, we are studying and practicing a new methodology called "meta-synthesis," a method by which problems are viewed, discussed, and resolved together. Specifically, this new methodology addresses human society, the economy, and natural environment as components of an interrelated system, in light of the various impacts to that system. Similarly, different disciplinary knowledge, techniques, experiences, and methods are integrated for EIA to produce a final result.

Henceforth, with the transition toward a market economy and the requirement of sustainable development influencing development in China, EIA will develop along two axes. Moving horizontally along the *x* axis, China will develop regional EIA and, along the vertical, or *y* axis, it will progress toward developing SEA and public policies which address more of the population's concerns. In addition, "sustainability related" impact and cumulative impact will be evaluated by more integrated methods and computer models (for example, GIS), and post-evaluation of EIA will be strengthened.

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6

Methods for Effective Environmental Information Assessment (EIA) Practice

L.W. Canter[1]

Abstract

Methods for facilitating the environmental impact assessment (EIA) process have been a subject of interest for over twenty-five years. This review highlights twenty-two types of methods relative to their potential usage for various impact study activities, changing usage patterns over time, and current relative applications in EIA. Key references which could be assembled for a basic EIA methods "tool kit" are identified. A typical impact study will probably involve the selection and usage of several methods for scoping, describing the affected environment, impact identification and quantification, and for the synthesis, interpretation, and communication of study findings.

Key Words: analogs, checklists, environmental cost-benefit analysis, expert opinion, expert systems, indicators, indices, interaction matrices, landscape evaluation, mass balance calculations, method, models, networks, overlay mapping, professional judgment, risk assessment

The search for the ideal method for satisfying all scientific and policy issues related to the environmental impact assessment (EIA) process has been ongoing since 1970. This search is illustrated by technical sessions on methods at annual meetings of professional societies such as the International Association for Impact Assessment (IAIA). Substantive area professional societies have also held technical conferences on impact methods for particular project types, and they have included related sessions at annual meetings. In addition, special meetings or studies have been conducted on the EIA process and associated methods (Centre for Environmental Management and Planning (CEMP) 1994; Cassios 1995; and Canter 1994). A common theme from these activities is that there is a continued need for the development of appropriate EIA methods.

Perspectives regarding the term *methods* have evolved over the twenty-five years of EIA practice. For example, in the early years *methods* typically denoted systematic approaches for identifying and integrating impact concerns; hence, they were seen as consisting of interaction matrices, networks, and checklists. Over time, methods have expanded to encompass scientific or policy tools or models which can be used to quantify, or at least descriptively address, the anticipated impacts of proposed actions on environmental media and resources. Methods also include decision analysis approaches for comparing and selecting a proposed action from several alternatives, monitoring for determining the effectiveness of mitigation measures, and techniques for public participation.

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As part of the recently completed International Study of the Effectiveness of Environmental Assessment (Sadler 1996), a specific effort was conducted on practical methods for the EIA process and on the selection of one to several methods for usage within the phases of a specific impact study (Canter and Sadler 1996). This paper summarizes the results related to types of methods useful for effective EIA practice. Furthermore, the identified methods may be considered as a "tool kit" for use by EIA practitioners.

Types of Methods

Numerous methods (tools) have been utilized over the last twenty-five years to meet the various activities required in the conduction of impact studies. The objectives of the various activities differ, as do the usable methods for each. Table 1 delineates twenty-two types of methods arrayed against seven typical study activities (Canter 1996a). An *x* denotes that the listed method type is or may be directly useful for a given activity. The types of methods in Table 1 encompass many specific techniques and tools. The methods are listed alphabetically rather than in order of importance or usage. Table 2 contains brief descriptions of each type of method.

EIA methods can be classified in other ways than the twenty-two types of methods shown in Table 1. Examples of other classification bases include: (1) activity within the study, wherein the method is expected to find the greatest usage, (2) "historical" usage vs. emerging methods, (3) simple methods relative to information needs, time, and fiscal requirements vs. advanced (or complex) methods which exhibit greater requirements, (4) qualitative or descriptive methods vs. quantitative methods, and (5) analytical methods for a specific substantive area (e.g., air quality synthesis methods which integrate information across substantive areas. It is beyond the scope of this paper to delineate these additional classifications.

Usage/Non-Usage of Methods

Table 3 displays the twenty-two types of methods against three time periods encompassing the first two decades of practice and the initial portion of the third decade. The initial emphasis on certain types of methods in a particular time period is shown, and continuing utilization is also denoted. It can be seen that the types of methods actually used have expanded over time.

Differential usage of methods has occurred within EIA practice, and Table 4 summarizes the relative usage into three categories. Methods which are simpler in terms of data and personnel resources requirements, and in technical complexity, have been found to be more useful. These simpler methods include analogs, checklists, expert opinion (professional judgment), mass balance calculations, and matrices.

An important consideration is that many impact studies have apparently not used any methods. A valid issue is thus related to situations or perspectives that would tend to encourage or discourage the use of methods. To illustrate, the following situations/ perspectives are conducive to the expanded usage of EIA methods:

- EIA legislation, regulations, and/or guidelines for the locale specify methods usage
- Expanding body of information on methods and dissemination of such information to EIA practitioners
- EIA practitioners perceive that methods usage is one aspect of responsible professional practice.

Table 1: Synopsis of EIA Methods and Study Activities

Types of Methods of EIA	Define Issues (scoping)	Impact Identific-ation	Describe Effected Environment	Impact Predicti-on	Impact Assess-ment	Decision Making	Results Commun-ication
Analogs (look alikes, case studies)	x	x		x	x		
Checklists (simple, descriptive, etc.)		x	x				x
Decision-focused checklists					x	x	x
Environmental cost-benefit analysis				x	x	x	
Expert opinion		x		x	x		
Expert systems	x	x	x	x	x	x	
Indices or indicators	x		x	x	x		x
Laboratory testing and scale models		x		x			
Landscape evaluation			x	x	x		
Literature reviews		x		x	x		
Mass balance calculations (inventories)				x	x		x
Matrices	x	x		x	x	X	x
Monitoring (baseline)			x		x		
Monitoring (field studies of receptors near analogs)				x	x		
Networks		x	x	x			
Overlay mapping via GIS			x	x	x		x
Photographs/montages			x	x			x
Qualitative modeling (conceptual)			x	x			
Quantitative modeling			x	x			
Risk assessment	x	x	x	x	x		
Scenario building				x		x	
Trend extrapolation			x	x			

X = potential for direct usage of method for listed activity

Table 2: Brief Descriptions of 22 Types of Methods

(1) Analogs refer to information from existing projects of a similar type to the project being addressed, with monitoring information related to experienced impacts being used as an analogy to the anticipated impacts of the proposed project.
(2) There are many variations of checklists, with this type of methodology being a frequently utilized approach. Conceptually, checklists typically contain a series of items, impact issues, or questions which the user should address.
(3) Decision-focused checklists are primarily related to comparing and conducting trade-off analyses for alternatives. In this regard, such methods are useful for the synthesis of information in relation to each viable alternative.
(4) Environmental cost-benefit analysis (ECBA) represents an emerging type of method. ECBA supplements traditional cost-benefit analysis with increased attention to the economic value of environmental resources, and to the valuation of impacts of the proposed project and alternatives on such resources.
(5) Expert opinion, also referred to as professional judgment, represents a widely used method. Specific tools which can be used to facilitate information development include the conduction of Delphi studies, the use of the adaptive environmental assessment process to delineate qualitative/quantitative models for impact prediction, or the separate development of models for environmental processes.
(6) Expert systems refer to an emerging type of method which draws upon the professional knowledge and judgment of experts in particular topical areas. Such knowledge is encoded, via a series of rules or heuristics, into expert system shells in computer software.
(7) Indices or indicators refer to selected features or parameters of environmental media or resources which represent broader measures of the quality/quantity of such media or resources. Specifically, indices refer to either numerical or categorized information which can be used in describing the effected environmental and impact prediction and assessment. Indices are typically based on selected indicators and their evaluation
(8) Laboratory testing and scale models refer to the conduction of specific tests and/or experiments to gain qualitative/quantitative information relative to the anticipated impacts of particular types of projects in given geographical locations.
(9) Landscape evaluation methods are primarily useful for aesthetic or visual resources assessment. Such are derived from indicators, with the subsequent aggregation of relevant information into an overall score for the environmental setting (similar to number 7).
(10) Literature reviews refer to assembled information on types of projects and their typical impacts. As noted for analogs, such information can be useful for delineating potential impacts, quantifying anticipated changes, and identifying mitigation measures.
(11) Mass-balance calculations refer to inventories of existing conditions in comparison to changes in such inventories that would result from the proposed action. Inventories are frequently used for air and water pollutant emissions, along with solid and hazardous wastes to be generated.
(12) Interaction matrices represent a widely used type of method within the EIA process. Variation of simple interaction matrices have been developed to emphasize particular desirable features.

Table 2 Cont.

(13) Monitoring (baseline) refers to measurements utilized to establish existing environmental conditions and interpret the significance of anticipated changes from a proposed action. (14) Monitoring (field studies) of receptors near analogs represents a specialized approach in that monitoring can be conducted of actual impacts resulting from projects of similar type to the project being analyzed. (15) Networks delineate connections or relationships between project actions and resultant impacts. They are also referred to as impact trees, impact chaines, cause effects diagrams, or consequence diagrams. Networks are useful for showing primary, secondary, and tertiary impact relationships. (16) Overlay mapping was used early in the practice of EIA, with the usage consisting of the assemblage of maps overlaying a base map and displaying different environmental characteristics. The application of geographical information systems (GIS) via computer usage has been an emphasis in recent years, with this technology representing an emerging type of method. (17) Photographs or photomonotages are useful tools for displaying the visual quality of the setting and the potential visual impacts of a proposed action. This type of method is related to landscape evaluation. (18) Qualitative modeling refers to methods wherein descriptive information is utilized to address the linkages between various actions and resultant changes in environmental components. Such modeling is typically based upon expert opinion (professional judgment as described earlier.) (19) Quantitative (mathematical) modeling refers to methods that can be used for specially addressing anticipated changes in environmental media or resources as a result of proposed actions. Quantitative models can encompass simplified models to very complicated three dimensional computer-based models that require extensive data input. (20) Risk assessment refers to an emerging tool initially used for establishing health-based environmental standards. It encompasses the identification of the risk, consideration of dose-response relationships, conduction of an exposure assessment, evaluation of the associated risks. Risk assessment can be viewed from the perspective of both human health and ecological risks. (21) Scenario building refers to considering alternative futures as a result of differing initial assumptions. Scenario building is utilized within the planning field, and it has EIA applicability, particularly in the context of strategic environmental assessments. (22) Trend extrapolation refers to methods that utilize historical trends and extend them into the future based upon assumptions related to either continuing or changed conditions.

Table 3: Changing Emphases on Types of Methods

Types of Methods in EIA	Emphasis in Time Period: 1970-79	1980-89	1990-now
Analogs (look alikes) (case studies)		I	C
Checklists (simple, descriptive, questionnaire)	I	C	C
Decision-focused checklists: MCDM, MAUM, DA, scaling/rating/ranking	I	C	C
Environmental cost-benefit analysis			I
Expert opinion (professional judgment, Delphi, adaptive assessment)		I	C
Expert systems (impact identification, prediction, assessment)			I
Indices or indicators		I	C
Laboratory testing and scale models		I	C
Landscape evaluation		I	C
Literature reviews		I	C
Mass balance calculations (inventories)	I	C	C
Matrices (simple, stepped, cross-impact, scoring)	I	C	C
Monitoring (baseline)		I	C
Monitoring (field studies of receptors near analogs)		I	C
Networks (impact trees/chains, cause/effect or consequence diagrams)	I	C	C
Overlay mapping via GIS			I
Photographs/photomontages (historical and current)		I	C
Qualitative modeling (conceptual)	I	C	C
Quantitative modeling (media, ecosystem, visual, archaeological, etc.)		I	C
Risk assessment (relative or quantitative and probabilistic)			I
Scenario building		I	C
Trend extrapolation		I	C

I = initial emphasis C = continuing emphasis
MCDM = multicriteria decision making MAUM = multiattribute utility measurement

- The EIA process is conducted during project planning and not as an afterthought" to other studies to justify previous decisions.
- The EIA process is viewed by the project proponent and EIA regulators as one component of a systematic planning process (rational planning model).
- Simpler methods are available for usage within the particular phase of the impact study.
- The proposed action is complex regarding its components and their potential impacts within the environmental setting.
- Adversarial litigation regarding the proposed action has already occurred or is anticipated.

In contrast, situations/perspectives which tend to be deterrents to methods usage include:

- Perception that the time required for impact study planning and conduction will be extended due to the usage of methods.
- Actual evidence or perception that the usage of methods will increase budgetary requirements for the impact study.
- Data or information requirements for methods usage are extensive and possibly even unavailable without excessive expenditures.
- EIA practitioners are not familiar with different types of methods and their advantages or limitations.
- Uncertainties are recognized related to the entire EIA process, or to specific methods such as quantitative models for impact prediction.
- The project proponent and/or EIA regulatory agency do not require or encourage the usage of methods.
- The EIA process is perceived as a planning and/or policy tool, thus specific scientific and quantitative approaches are not considered to be needed.
- EIA practitioners perceive that methods will become overscrutinized and criticized in the event of subsequent litigation.

In summary, while many EIA methods exist, they are not uniformly used in all impact studies. Conversely, perhaps the greatest encouragement is that, as more information becomes available on EIA methods and their interrelationships, this can be a major inducement to methods usage. Therefore, the assemblage of a "library" of key references can be of value to EIA practitioners. Table 5 delineates several key references organized by topical issue for such a library. The listed references represent a basic "methods tool kit" for EIA practitioners.

Summary

EIA methods may also be referred to as "methodologies," "techniques," "tools," or "models." EIA practitioners should recognize that a variety of terms may be used to describe the plethora of available methods. As EIA practice matures, it is possible that a typology of terms (and methods) will be developed; however, such a typology is not currently available. Finally, based upon the brief review of EIA methods included herein, the following observations can be made:

- Regarding Table 1, each listed type of method has potential usefulness in two to as many as six EIA study activities. Also, each listed activity has four to as many as nineteen listed method types which are potentially useful. Each of the listed types of methods have advantages and limitations; these should be considered in selecting specific methods for usage.

Table 4: Summary of Relative Usage of Types of Methods

Types of Methods	Relative Usage: Selected	Moderate	Widespread
Analogs			X
Checklists			X
Decision-focused checklists	X		
Environmental cost-benefit analysis	X		
Expert opinion			X
Expert systems	X		
Indices or indicators		X	
Laboratory testing and scale models	X		
Landscape evaluation	X		
Literature reviews		X	
Mass balance calculations			X
Matrices			X
Monitoring (baseline)	X		
Monitoring (analogs)	X		
Networks		X	
Overlay mapping via GIS	X		
Photographs/montages		X	
Qualitative modeling		X	
Quantitative modeling	X		
Risk assessment	X		
Scenario building	X		
Trend extrapolation	X		

Selected: limited usage of type of methods; such limits could be due to data requirements, limited knowledge about the method, or the fact that it is an emerging method.
Moderate: the type of method is used for different types of projects in different locations.
Widespread: the type of method widely used in a variety of countries with EIA requirements.

Table 5: Key References

Topic	Key References
Policies, procedures, and/or guidelines	Gilpin (1995), Roe, Dalal-Clayton, and Hughes (1995), Sadler (1996), Wood (1995), World Bank (1991a)
Impact identification, prediction, and decision making	Canter (1996b), Morris and Therivel (1995), Turnbull (1992), Vanclay and Bronstein (1995)
Physical-chemical impacts (air, surface and ground water, and noise)	James (1993), Magrab (1975), Turner (1994), Water Science and Technology Board (1990)
Biological or ecological impacts	Marsh (1991)
Aesthetic or visual impacts	Smardon, Palmer, and Felleman (1986)
Social or socioeconomic impacts (including health and risks)	Asian Development Bank (1992), Birley (1995), Canter, Atkinson, and Leistritz (1985), Interorganizational Committee on Guidelines and Principles for Social Impact Assessment (1994), Paustenbach (1989), Taylor, Bryan, and Goodrich (1995)
Specific examples (see note)	Carpenter (1994) -- railways Council on Environmental Quality (1996) -- cumulative impacts Economic and Social Commission for Asia and the Pacific (1990) -- highways and dams Federal Environmental Assessment Review Office (1988) -- public participation Petts and Eduljee (1994) -- waste treatment and disposal facilities Sadler and Davies (1988) -- monitoring and auditing Sadler and Verheem (1996) -- strategic environmental assessment Winpenny (1991) -- economic valuation of impacts World Bank (1991b) -- sectoral projects World Bank (1991c) -- energy and industry projects

Note A: Additional examples related to type of projects or specific impact issues could be cited.

- In a given impact study, several types of methods will probably be used even though the resultant impact report—for example, an environmental impact statement (EIS)—may not completely document all of the utilized methods.
- While numerous types of methods have been developed and additional ones are emerging, there is no "universal" method which can be applied to all proposed actions in all environmental settings and for all study activities. Accordingly, the most appropriate perspective is to consider methods as "tools" which can be selected and modified as appropriate to aid the EIA process.
- Integration of the results from methods usage is a key consideration in planning and conducting an efficient and effective impact study. Such integration enables the appropriate synthesis of study findings.

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7

The Concept of Environmental Sustainability (ES)[1]

Robert Goodland[2]

Abstract

This paper reviews the current status of the debate about the concept of environmental sustainability and discusses related aspects of growth, limits, scale, and substitutability. While the paths leading to environmental sustainability in each country or sector will differ, the goal remains constant. But this conceptualization is far from an academic exercise. Ensuring, within less than two human generations, that as many as ten billion people are decently fed and housed without damaging the environment on which we all depend represents a monumental challenge.

Key Words: sustainability, environmental sustainability, sustainable development, social sustainability, substitutability, carrying capacity growth vs. development.

Introduction

This paper seeks to define environmental sustainability partly by sharply distinguishing it from social sustainability and, to a lesser extent, from economic sustainability. These are contrasted in Figure 1. While overlap exists among the three, economic sustainability and ES have especially strong linkages. Defining each component of sustainability distinctly helps organize the action required to approach global sustainability. General sustainability may come to be based on all three aspects—environmental, social, and economic.

Environmental sustainability focuses on that portion of the natural resource base that provides physical inputs, both renewable (e.g., forests) and exhaustible (e.g., minerals), into the production, emphasizing environmental life-support systems without which neither production nor humanity could exist. These life-support systems include: atmosphere, water, and soil—all of these need to be healthy, meaning that their environmental service capacity must be maintained.

Social Sustainability

The environment has now become a major constraint on human progress. Fundamentally important though social sustainability is, environmental sustainability or maintenance of life-support systems is a prerequisite for social sustainability. Poverty reduction is the primary goal of sustainable development, even before environmental quality can be fully addressed. Poverty is increasing in the world in spite of global and national economic growth. Poverty reduction has to come from qualitative development, from redistribution and sharing, from population stability, and from community sodality,

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[1] This paper is extracted from Goodland 1995.

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Social Sustainability Achieved only by systematic community participation and strong civil society. Cohesion of community, cultural identity, diversity, sodality, comity, tolerance, humility, compassion, patience, forbearance, fellowship, fraternity, institutions, love, pluralism, commonly accepted standards of honesty, laws, discipline, etc., constitute the part of social capital least subject to rigorous measurement, but for social sustainability. This "moral capital," as some call it, requires maintenance and replenishment by shared values and equal rights, and by community, religious, and cultural interactions. Without this care it will depreciate as surely as will physical capital. Human capital—investments in education, health, and nutrition of individuals—is now accepted as part of economic development, but the creation of social capital as need for social sustainability is not yet recognized adequately.

Economic Sustainability Economic capital should be stable. The widely accepted definition of economic sustainability is "maintenance of capital," or keeping capital intact. Thus Hicks' definition of income—"the amount one can consume during a period and still be as well off at the end of the period"—can define economic sustainability, as it devolves on consuming interest rather than capital. Economics has rarely been concerned with natural capital (e.g., uncut forests, clean air). To the traditional economic criteria of allocation and efficiency must now be added a third, that of scale. The scale criterion would constrain throughput growth—the flow of material and energy (natural capital) from environmental sources to sinks. Economics values things in monetary terms, and is therefore having major problems valuing natural capital—intangible, intergenerational, and, especially, common access resources such as air. Because people and irreversibles are at stake, economics needs to use anticipation and the precautionary principle routinely, and should err on the side of caution in the face of uncertainty and risk.

Environmental Sustainability (ES) Although ES is needed by humans and originated because of social concerns, ES itself seeks to improve human welfare by protecting the sources of raw materials used for human needs and ensuring that the sinks for human wastes are not exceeded, in order to prevent harm to humans. Humanity must learn to live within the limitations of the biophysical environment. ES means natural capital must be maintained, both as a provider of inputs ("sources") and as a "sink" for wastes. This means holding the scale of the human economic subsystem to within the biophysical limits of the overall ecosystem on which it depends. ES needs sustainable consumption. On the sink side, this translates into holding waste emissions within the assimilative capacity of the environment without impairing it. On the source side, harvest rates of renewables must be kept within regeneration rates. Non-renewables cannot be made fully sustainable, but quasi-ES can be approached for non-renewables by holding their depletion rates equal to the rate at which renewable substitutes can be created (El Serafy 1993; Fritsch, Schmidheiny, and Seifritz 1994).

Figure 1. Comparison of Social, Economic, and Environmental Sustainability

rather than only from throughput growth. Politicians will doubtless want the *impossible* goal of increasing throughout—the flow of materials and energy from the sources of the environment, used by the human economy, and returned to environmental sinks as waste—by increasing consumption by all.

Countries truly sustaining themselves, rather than liquidating their resources, will be more peaceful than countries with unsustainable economies (Goodland 1994). Countries with unsustainable economies—those liquidating their own natural capital or those importing liquidated capital from other countries (e.g., Middle East oil or tropical timber "mining") are more likely to wage war than are those with sustainable economies.

Sustainability and Development

Sustainable development should integrate social, environmental, and economic sustainability and use these three to start to make development sustainable. The moment the term development is introduced, however, the discussion becomes more ambiguous. This paper is not focused on sustainable development, here assumed to be development that is socially, economically, and environmentally sustainable, or "development without throughput growth beyond environmental carrying capacity and which is socially sustainable."

The priority for development should be improvement in human well-being—the reduction of poverty, illiteracy, hunger, disease, and inequity. While these development goals are fundamentally important, they are quite different from the goals of environmental sustainability, the unimpaired maintenance of human life-support systems—the environmental sink and source capacities.

Intergenerational and Intragenerational Sustainability

Most people in the world today are either impoverished or live barely above subsistence; the number of people living in poverty is increasing. Developing countries can never be as well off as today's OECD (Organization for Economic Cooperation and Development) average. Future generations seem likely to be larger and poorer than today's generation. Sustainability includes an element of not harming the future (intergenerational equity), as well as not harming the society today (intragenerational equity). If the world cannot move toward intragenerational sustainability during this generation, it will be that much more difficult to achieve intergenerational sustainability sometime in the future, for the capacity of environmental services will be lower in the future than it is today, and the world's population will be much greater.

World population soars by 100 million people each year. Some of these people are OECD overconsumers, but most of them are poverty stricken. World population doubles in a single human generation—about forty years. This makes achieving intergenerational equity difficult, although achieving intergenerational equity will probably reduce total population growth. Rather than focusing on the intergenerational equity concerns of ES, the stewardship approach of safeguarding life-support systems today seems preferable.

What Should Be Sustained?

Environmental sustainability seeks to sustain global life-support systems indefinitely (this refers principally to those systems maintaining human life). Source capacities of the global ecosystem provide raw material inputs—food, water, air, energy; sink capacities assimilate outputs or wastes. These source and sink capacities are large but finite; sustainability requires that they be maintained rather than run down. Overuse of a capacity impairs its provision of life-support services. For example, accumulation of CFCs is damaging the capacity of the atmosphere to protect humans and other biota from harmful ultraviolet radiation.

Protecting human life is the main reason anthropocentric humans seek environmental sustainability. Human life depends on other species for food, shelter, breathable air, plant pollination, waste assimilation, and other environmental life-support services. The huge instrumental value of nonhuman species to humans is grossly undervalued by economics. Nonhuman species of no present value to humans have intrinsic worth, but this consideration is almost entirely excluded in economics (exceptions are existence and option values). A question rarely posed by economists and not yet answered by any is:

With how many other species is humanity willing to share the earth, or should all other species be sacrificed to make room for more and more of the single human species? Surely it is arrogant folly to extinguish a species just because we think it is useless today.

Growth Compared with Development

The dictionary distinguishes between growth and development. "To grow" means "to increase in size by the assimilation or accretion of materials"; "to develop" means "to expand or realize the potentialities of; to bring to a fuller, greater, or better state."

Growth implies quantitative physical or material increase; development implies qualitative improvement or at least change. Quantitative growth and qualitative improvement follow different laws. Our planet develops over time without growing. Our economy, a subsystem of the finite and nongrowing earth, must eventually adapt to a similar pattern of development without growth. The time for such adaptation is now. Historically, an economy starts with quantitative throughout growth as infrastructure and industries are built, and eventually it matures into a pattern with less throughput growth but more qualitative development.

The Definition of Environmental Sustainability

The definition of ES as the "maintenance of natural capital" constitutes the input/output rules in Figure 2.

The two fundamental environmental services—the source and sink functions—must be maintained unimpaired during the period over which sustainability is required. ES is a set of constraints on the four major activities regulating the scale of the human economic subsystem: the use of renewable and nonrenewable resources on the source side, and pollution and waste assimilation on the sink side. This short definition of ES is the most useful so far and is gaining adherents. The fundamental point to note about this definition is that ES is a natural science concept and obeys biophysical laws (Figure 2). This general definition seems to be robust irrespective of country, sector, or future epoch.

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1. *Output Rule*: Waste emissions from a project or action being considered should be kept within the assimilative capacity of the local environment without unacceptable degradation of its future waste absorptive capacity or other important services.

2. Input Rule: (a) Renewables: harvest rates of renewable resource inputs should be within regenerative capacities of the natural system that generates them.
   (b) Nonrenewables: depletion rates of nonrenewable resource inputs should be set below the rate at which renewable substitutes are developed by human invention and investment according to the Serafian quasi-sustainability rule. An easily calculable portion of the proceeds from liquidating nonrenewables should be allocated to pursuit of sustainable substitutes.

Figure 2. The Definition of Environmental Sustainability

The paths needed by each nation to approach sustainability will not be the same. Although all countries need to follow the input/output rules, countries differ in the balance of attention between output and input that will be needed to achieve ES. For example, some countries or regions must concentrate more on controlling pollution (e.g., former centrally planned economies); some countries must pay more attention to bringing harvest rates of their renewable resources down to regeneration rates (e.g., tropical timber-exporting countries); some countries must bring their population to below carrying capacity; other must reduce their per capita consumption (e.g., all OECD countries).

There are compelling reasons why industrial countries should lead in devising paths toward sustainability. They have to adapt far more than do developing countries. If OECD countries cannot act first and lead the way, it is less likely that developing countries will choose to do so. Not only would it be enlightened self-interest for the north to act first, but it could also be viewed as a moral obligation. Second, developing countries are rightly pointing out that OECD countries have already consumed substantial amounts of environmental sink capacity (e.g., nearly all CFCs that are damaging the atmosphere were released by OECD countries) as well as source capacity (e.g., several species of great whales are extinct, and many stocks of fish and tropical timbers have been depleted below economically harvestable levels). Third, OECD countries can afford the transition to sustainability because they are richer. The rich would do themselves good by using the leeway they have for cutting overconsumption and waste.

Natural Capital and Sustainability

Of the four kinds of capital (natural, human, human made, and social), environmental sustainability requires maintaining natural capital; understanding ES thus includes defining "natural capital" and "maintenance of resources" (or at least "non-declining levels of resources"). Natural capital—the natural environment—is defined as the stock of environmentally provided assets (such as soil, atmosphere, forests, water, wetlands), which provide a flow of useful goods or services; these can be renewable or nonrenewable, and marketed or nonmarketed. Sustainability means maintaining environmental assets, or at least not depleting them. "Income" is sustainable by the generally accepted Hicksian definition of income. Any consumption that is based on the depletion of natural capital is not income and should not be counted as such. Prevailing models of economic analysis tend to treat consumption of natural capital simply as income and therefore tend to promote patterns of economic activity that are unsustainable. Consumption of natural capital is liquidation, or disinvestment—the opposite of capital accumulation.

Now that the environment is so heavily used, the limiting factor for much economic development has become natural capital. For example, in marine fishing, fish have become limiting, rather than fishing boats. Timber is limited in its deposits and atmospheric capacity to absorb CO_2, not by refining capacity. As natural forests and fish populations become limited, we begin to invest in plantation forests and fish ponds. This introduces an important hybrid category that combines natural and human-made capital—a category we may call "cultivated natural capital." This category is vital to human well being, accounting for most of the food we eat, and a good deal of the wood and fibers we use. The fact that humanity has the capacity to "cultivate" natural capital dramatically expands the capacity of natural capital to deliver services. But cultivated natural capital (agriculture) is separable into human-made capital (e.g., tractors, diesel irrigation pumps, chemical fertilizers, biocides) and natural capital (e.g., topsoil, sunlight, rain). Eventually the natural capital proves limiting.

Natural Capital Is Now Scarce

In an era in which natural capital was considered infinite relative to the scale of human use, it may have been reasonable not to deduct natural capital consumption from gross receipts in calculating income. That era is now past. Environmental sustainability needs the conservative effort to maintain the traditional (Hicksian) meaning and measure of income now that natural capital is no longer a free good but is more and more the limiting factor in development.

Three Degrees of Environmental Sustainability

Sustainability can be divided into three degrees—weak, strong, and absurdly strong—depending on how much substitution one thinks there is among the four types of capital (natural, human, human-made, and social) (Daly and Cobb 1989):

- *Weak environmental sustainability*: Weak ES is maintaining total capital intact without regard to the partitioning of that capital among the four kinds. This would imply that the various kinds of capital are more or less substitutes, at least within the boundaries of current levels of economic activity and resource endowment. Given current liquidation and gross inefficiencies in resource use, weak sustainability would be a vast improvement as a welcome first step but would by no means constitute ES. Weak sustainability is a necessary but not sufficient condition for ES.
- *Strong environmental sustainability*: Strong ES requires maintaining separate kinds of capital. Thus, for natural capital, receipts from depleting soil should be invested in ensuring that energy will be available to future generations at least as plentifully as that enjoyed by the beneficiaries of today's oil consumption. This assumes that natural and human-made capital are not perfect substitutes. On the contrary, they are complements at least to some extent in most production functions. A sawmill (human-made capital) is worthless without the complementary natural capital of a forest. Of the three degrees of sustainability, strong sustainability seems greatly preferable mainly because of the lack of substitutes for much natural capital, the fact that natural capital and not human-made capital is now limiting, and the need for prudence in the face of many irreversibilities and uncertainties.
- *Absurdly strong environmental sustainability*: We would never deplete anything. Nonrenewable resources—absurdly—could not be used at all. All minerals would remain in the ground. For renewables, only net annual growth increments could be harvested in the form of the overmature portion of the stock.

There are tradeoffs between human-made capital and natural capital. Economic logic requires us to invest in the limiting factor, which now is often natural rather than human-made capital, which was previously limiting. Operationally, this translates into three concrete actions as noted in Figure 3.

Sustainability and Substitutability

Conventional economics and technological optimists depend heavily on substitutability as the rule rather than the exception. The extent of substitutability between natural and human-made capital is central to the issue of sustainability. Substitutability is the ability to offset a diminished capacity of environmental source and sink services to provide healthy air, water, etc., and to absorb wastes. The importance of substitutability is that if it prevails, then there can be no limits, because if an environmental good is destroyed, it is argued, a substitute can replace it. When white pine or sperm whales became scarce, there were acceptable substitutes. When easily gathered surficial oil flows were exhausted, drilling technology enabled very deep deposits to be tapped. In Europe, when the native forest was consumed, timber for houses was replaced with brick. If bricks did not substitute for timber, then timber was imported.

1. FOSTER REGENERATION OF NATURAL CAPITAL: Encourage the growth of natural capital by reducing our current level of exploitation of it. For example, lengthen rotations (of forest cutting or arable crops) to permit full regeneration; limit catches (e.g., of fish) to prudently well within long-term sustained yield estimates.
2. RELIEVE PRESSURE ON NATURAL CAPITAL: Invest in projects to relieve pressure on natural capital stocks by expanding cultivated natural capital, such as tree plantations to relieve pressure on natural forests. Reducing pollution and waste provides more time for assimilative capacities to regenerate themselves.
3. IMPROVE EFFICIENCY IN USE OF NATURAL CAPITAL:Increase the end-use efficiency of products (such as improved cookstoves, solar heaters and cookers, wind pumps, solar pumps, manure rather than chemical fertilizer). ` Extend the life-cycle, durability, and recyclability of products to improve overall efficiency, as would planned obsolescence and ephemerata.

Figure 3. Rebuilding Natural Capital Stocks

The realization that substitutability is the exception, rather than the rule, is not yet widespread. However, once limits of imports cease to mask substitutability (e.g., U.S. Pacific Northwest and British Columbia timber controversies show the limits of imports), then it becomes plain that most (but not all) forms of capital are more complementary.

Ecologists attach great importance to Baron Justus von Liebig's Law of the Minimum—the whole chain is only as strong as its weakest link. The factor in shortest supply is the limiting factor because factors are complements, not substitutes. If scarcity of phosphate is limiting the rate of photosynthesis, then photosynthesis would not be enhanced by increasing another factor such as nitrogen, light, water, or CO_2. If one wants faster photosynthesis, one must ascertain which factor is limiting and then invest in that one first, until it is no longer limiting. More nitrogen fertilizer cannot substitute for lack of phosphate, precisely because they are complements. Environmental sustainability is based on the conclusion that most natural capital is a complement for human-made capital, and not a substitute. Complementarity is profoundly unsettling for conventional economics because it means there are limits to growth, or limits to environmental source and sink capacities. Human-made capital is a very poor substitute for most environmental services. Substitution for some life-support systems is impossible.

A compelling argument that human-made capital is only a marginal substitute for natural capital is the reductio ad absurdum case in which all natural capital is liquidated into human-made capital. We might survive the loss of fossil fuels, but what would substitute for topsoil and breathable air? Only in science fiction could humanity survive by breathing bottled air from backpacks, and eating only hydroponic greenhouse food. If there is insufficient substitutability between natural capital and human-made capital, then throughput growth must be severely constrained and eventually cease. While new technology may postpone the transition from quantitative growth to qualitative development and environmental sustainability, current degradation shows that technology is inadequate. For natural life-support systems no practical substitutes are possible, and degradation may be irreversible. In such cases (and perhaps in others as well), compensation cannot be meaningfully specified.

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This paper should in no way be construed as the official position of the World Bank Group.

8

Strategic Environmental Assessment

Ralf Buckley[1]

Abstract

Strategic environmental assessment (SEA) is currently the single most important direction in EA. The main forms of SEA include policy, issue-based, geographical, temporal, technological, sectoral, and generic-project EA. SEA of policies and associated legislative proposals is most critical. Without policy SEA, governments can and do adopt unsustainable policies that override the effects of project-scale EA. Policy SEA has been provided for informal EA frameworks in some countries, including the U.S. and Australia, since these were first established decades ago. However, it is rarely carried out in practice. Formal and enforceable mechanisms to trigger SEA of government policies, and incorporate the outcomes into policy and legislation, need to be pursued worldwide.

Key Words: strategic, policy, technology, sector, region, trade

Introduction

The term "strategic environmental assessment" has become widespread in environmental policy documents in recent years (World Bank 1992; Wood and Djeddour 1992; Therivel et al. 1992; Therivel 1993; Australia Commonwealth Environmental Protection Agency (CEPA) 1994; Buckley 1994a; Denmark 1994; Sadler 1994; Goodland and Edmundson 1994; Gilpin 1995; Ortolano and Shepherd 1995; Roe, Dalal-Clayton, and Hughes 1995; Thompson, Treweek, and Thurling 1995).

Definitions vary. Ortolano and Shepherd (1995) described SEA broadly as "EA in strategic planning and policymaking." Buckley (1994a) listed seven different major types of SEA:

- policy: environmental assessment of existing policies or proposed changes
- issue-based: assessment of factors relating to a specified environmental issue
- geographical: regional and national environmental planning and assessment
- temporal: environmental planning and assessment for social and economic change
- technological: environmental assessment for technological innovation
- sectoral: EA for alternative development options for entire industry sectors
- generic-project: framework EIA (environmental impact assessment) documents for similar projects.

Here I review each of these briefly, examining its rationale, case studies, current status, and obstacles to more effective implementation. Policy SEA is arguably the most significant, and is therefore covered in most detail.

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Policy SEA

Rationale

Large-scale government policies commonly have more far-reaching effects than even the largest single development projects. SEA of policies and associated legislative proposals, therefore, also known as policy assessment (Boothroyd 1995) is arguably the most critical type of SEA. Without policy-level EA, nations can and do continue on unsustainable development paths, despite project-scale EIA. Indeed, Boothroyd essentially argues that some governments knowingly use project-scale EIA as standard operating procedure in response to public concerns over environmental sustainability.

There are many reasons why project-scale EIA is much more common than policy-scale SEA even in nations such as the U.S. and Australia, whose EIA legislation covers both (Boothroyd 1995):

- It is technically simpler to predict first-order physical impacts at a local scale than higher-order environmental impacts of socioeconomic changes at a national scale.
- There are more opportunities to mitigate impacts at project scale, even though this often involves shifting them elsewhere so that at a broader scale this mitigation may be illusory.
- Most policymaking is secretive because it involves political contention between different interest groups.
- The most powerful policies are often unwritten, unspoken, unacknowledged, and hence not open to formal assessment.

Policy SEA, however, can yield a number of benefits which generally do not accrue from project-scale EIA (Wood and Djeddour 1992; Buckley 1994a, b; Boothroyd 1995).

- It involves more government agencies and a more representative cross-section of the electorate.
- It can achieve increased efficiency through economies of scale.
- It can canvass, consider, and compare a wider range of development options.
- It provides a much more effective mechanism for assessing impacts, particularly if coupled with geographical, temporal, and/or sectoral SEA.

Applications

Some examples of the types of policy which should be subject to SEA (Buckley 1994a), even though they rarely are in practice, are listed below. In most democratic nations, responsibility for these aspects of policy is shared between a range of government agencies:

- international trade, finance and economic agreements, and their subsidiary codes
- international military and defense agreements
- bilateral and multilateral development assistance programs
- ratification of international conventions
- other international governmental agreements
- interstate agreements in federated nations
- tax regimes, including resource royalties, rebates, and deductions, etc.
- government spending priorities and programs, e.g., in primary industries, energy, transport, and infrastructure
- investment constraints and incentives
- government policies on foreign ownership or equity of land, businesses, and other property rights.

Examples

International trade agreements provide an excellent case study. International trade agreements, most powerfully the General Agreement on Tariffs & Trade (GATT), place significant constraints on domestic environmental legislation by signatory nations (Anderson and Blackhurst 1992; Buckley 1992, 1993a, 1994c; Charnovitz 1992, 1994; McDonald 1993; Cameron, Demarot, and Gerardin 1994; Esty 1994; Ulph 1996). Indeed, these constraints have tightened in recent years following a series of international disputes (McDonald 1993; Buckley and Wild 1994; Keys 1994). For most nations the aggregate environmental consequences of signing the Uruguay Round GATT agreements and joining the World Trade Organization are likely to be far greater than those of individual development projects; yet in most nations, the former is treated as the prerogative of the foreign affairs portfolio, exempt from EA by the environment portfolio. In Australia, for instance, while staff of the Department of Foreign Affairs & Trade agreed in principle to EA of Australian ratification of the Uruguay Round agreements (Drake-Brockman 1994), in practice this was internal and informal with no opportunity for formal public involvement. The federal government made no attempt to provide public information, and the principal source was *via* international environmental organizations. Their information in turn was derived largely from their counterparts in the U.S., where there was a very active policy debate.

Similar issues arose for the North American Free Trade Agreement (NAFTA) (Buckley 1992, 1994c; Hufbauer and Schott 1993). The official Canadian government SEA of NAFTA (Canada 1992) concluded that NAFTA would not produce any environmental problems. Whether naive or politically motivated, it ignored or failed to identify a wide range of potentially significant environmental problems (Buckley 1992; Daly and Goodland 1994; Keys 1994; Boothroyd 1995) which led to extensive policy debate in the U.S., a court challenge, and ultimately to the establishment of an environmental side agreement. The court challenge argued that the U.S. government's accession to NAFTA was subject to EA under the U.S. National Environmental Policy Act 1969 (NEPA). The challenge was initially successful, though overturned on appeal (Keys 1994). At least NEPA provides an avenue for such cases to be brought; though since its provisions are primarily procedural rather than substantive, the U.S. government could ultimately have proceeded even if EA had identified significant environmental impacts.

International development assistance, whether in cash or kind, provides a second major example. There has been extensive debate in nations such as the U.S. and Australia as to whether bilateral aid programs by agencies such as the U.S. Agency for International Development (USAID) and the Australian International Development Assistance Bureau (AIDAB), and national contributions to multilateral lending institutions such as the World Bank, should be subject to federal EA legislation. Clearly they should, in both countries. In Australia, for example, this was established by the attorney-general during a senate inquiry in 1989 (Australia Senate 1989); but the environment minister did not force the issue to court, and indeed allowed AIDAB to conduct its own internal EA (AIDAB 1992). Other countries do likewise (Finland 1989; Japan 1992; U.K. 1992; Organization for Economic Cooperation and Development (OECD) 1992; Canada 1994; Roe Dalal-Clayton, and Hughes 1995). Similarly, the World Bank conducts its own assessments under an internal operational directive (World Bank 1992, 1993) as do other multilateral development banks (e.g., African Development Bank (ADB) 1992).

Current Status

The U.S. *National Environmental Policy Act* 1969 (NEPA) has been interpreted by the U.S. Congress and courts to include EA for federal policies and proposed federal legislation, i.e., policy SEA. A recent High Court decision in Australia has specified that even approvals in principle by federal government, although they confer no immediate legal rights, are subject to federal EIA legislation. The case arose from an approval in principle for woodchip exports, even though licences are still required.

In practice, however the povisions of U.S. NEPA have been used principally for regional rather national-policy SEA (Wood 1995). Similarly Therivel (1993) found that SEAs prepared to that date had been carried out exclusively for plans and programs rather than policies.

Judging from the recent comparative study by Wood (1995), countries may currently be grouped into four major categories on the basis of their institutional framework for SEA:

- SEA provided for om principle in legal frameworks and also carried out formally in practice, though only occasionally: U.S. only
- SEA provided for in principle but not carried out formally in practice: though it may occasionally be carried out informally: e.g., Australia and New Zealand (see AIDAB 1992)
- SEA carried out informally, in practice but not in principle: e.g., Canada, Netherlands, U.K. (see Gardiner 1994; Howard and Bunce 1996)
- SEA not provided for either in principle or practice: most countries (Roe, Dalal-Calyton, and Hughes 1995).

Obstacles

As with project-level EIA, there are four major components to any effective framework for SEA: triggering mechanism, technical assessment, decision, and follow-up and feedback. As with project-level EIA, the only effective triggering mechanism is a mandatory legal requirement with clearly defined criteria, and third-party recourse to court enforcement. Political discretion is simply not an effective triggering mechanism (Buckley 1991a; Wood 1995; Buckley and Warnken, this volume); and even less so for policy than at project scale. Even where SEA is ordered by the courts, it can still be avoided by adroit political maneuvering, as in the case of U.S. trade agreements as outlined above.

Even if policy SEA is triggered effectively, it is still technically more difficult and uncertain than project-scale EIA, because the environmental effects of policy or legislation will depend on intermediate social and economic effects, and relevant predictions are less precise than models of well-defined physical impacts on the natural environment. The precision and detail required of policy SEA, however, is generally far less than that for project-scale EIA. Predictions are still technically feasible; uncertainty can still be estimated; and the outcome may be orders of magnitude more important. In addition, many of the issues which need to be considered have already been identified and investigated for several years in the context of environmental audits for planning procedures and legislation (Buckley 1991b).

One of the most serious deficiencies in frameworks for policy SEA is that there is rarely any formal mechanism for it to influence the decision whether or not to adopt the policy under assessment, and if so, whether policy or legislation should be modified to reduce or mitigate environmental impacts. In countries with formal legal provision for SEA, the legal framework does, in theory, provide an avenue for a proposed law or policy to be abandoned if its environmental impacts are too deleterious. Since the provisions of U.S. NEPA are almost entirely procedural rather than substantive, however—as with most EIA legislation worldwide—a policy may still be adopted even if it is assessed to have substantial environmental impacts. The same would apply in Australia, if indeed the provisions of the *Environmental Protection (Impact of Proposals) Act* 1974 (Commonwealth) or State EIA laws were used to invoke policy SEA.

Recommendations

Clearly, policy SEA needs to be applied regularly and routinely to all government policy and legislative proposals. This requires EA legislation which triggers SEA automatically whenever a formal policy document is tabled or a bill introduced with general public standing to enforce the process.

Issues, Regions, Change, & Technology

Issue-based SEA

Issue-based approaches are essentially a limited category of policy EA. They aim to assess the impacts of all relevant sectors of the economy on a single environmental management issue, such as biodiversity conservation or reduction of greenhouse gas emissions (Taplin and Braaf 1995, Bando 1996). The National Biodiversity Strategy (Australia Endangered Species Advisory Committee 1992) and the Australia ESD Greenhouse Report (Australia Ecological Sustainable Development Working Group Chairs 1992) provide examples in Australia. In Canada, the National Roundtable on Environment and Economy takes a largely issue-based strategic approach. Issues-based strategic EA is proving to be a very valuable planning tool at a national scale.

The main advantage of issue-based SEA is the cross-sectoral approach, which reduces the likelihood that environmental problems will be shunted between sectors and ultimately ignored. It is therefore most useful if coupled with sectoral EA, as in the Australian ESD process. Few if any countries, however, have formal mechanisms to trigger issue-based SEA, or to act on its outcomes. More commonly, it is carried out as part of an overtly political process (Doyle and Kellow 1995). The reports of the Australian ESD Working Groups, for example, were largely ignored following a change in prime minister, even though of the same political party. Since there are no immediately apparent triggering criteria for issue-based SEA, it is likely to remain an informal process, but a very valuable one nonetheless.

Geographical SEA

Geographical SEA, either at a regional or broader scale, has been trialed in many countries but is not used routinely. Its rationale is an integrated assessment of environmental issues for past, current and proposed developments and land uses throughout an entire region. This is particularly valuable where ecological regions cross jurisdictional boundaries, as many do. In Australia, for example, the state of New South Wales has prepared a number of regional environmental plans (REPs) (Gilpin 1995), but does not use them as a routine part of formal planning processes. It relies instead on local environmental plans (LEPs) and the state environmental planning policies (SEPPs). Despite calls for more extensive use of REPs for over a decade (Buckley 1986a, b, c), it is still not a routine tool in Australia. Similarly, though there are U.S. examples such as the REA (Regional Environmental Assessment) for oil and gas exploration and production in coastal Alabama and Mississippi by the U.S. Army Corps of Engineers (World Bank 1992), these are the exception rather than the rule.

One obstacle to broader use of geographical SEA appears to be funding (Buckley 1986a, b, c, d, 1988, 1991c). If government funds regional SEA, as generally occurs at present, are there any mechanisms to recover costs from major beneficiaries? For example, if development proponents could gain approval for a project simply by showing that it conformed to a REP, avoiding the requirement for project-specific EIA, should they be required to make a financial contribution to the REP in lieu of the costs of preparing an EIS? If, however, conformity with an REP were a necessary but not sufficient condition for development approval, and normal EIA requirements still applied, then the proponents would not gain any particular cost saving and would not be specific beneficiaries (Buckley 1994a).

For geographical SEA which crosses jurisdictional boundaries, there may also be a political issue. State governments do not like to be bound by agreements with their neighbors unless the agreement gives them a clear advantage. Commonly, therefore, states jockey for position and never agree on the outcome (Buckley 1986a). Technical difficulties may also apply, but are not insurmountable (e.g., Kamari 1990).

Temporal SEA

Planning for social and economic change is in theory one of the routine functions of governments at all levels. A number of government agencies, industry associations, large corporations, privately funded think-tanks, and academic institutions have interests and expertise in predicting possible changes and assessing the consequences for themselves or their clients or constituencies. Few if any countries, however, have formal frameworks for temporal SEA, and in practice it occurs only as one component of policy, issue-based, sectoral or technology SEA. These, however, do not span all the relevant issues. There is still a need for SEA of actual large-scale social, demographic and economic trends as a *basis* for identifying issues and formulating policy, as well as SEA of policies already formulated and major issues already identified.

Technological SEA

SEA of new technologies and technological change is an important issue, as shown by the number of major environmental issues considered by the U.S. Office of Technology Assessment (USOTA) in recent years. Examples range from biotechnologies to resource recovery and recycling technologies, energy generation and transmission to ozone-friendly refrigerators, minimum-tillage harrows to wave-piercing catamarans (USOTA 1992). There is currently no formal mechanism for SEA of new technologies in most countries, however, except very indirectly through licensing requirements in some contexts. Indeed, few countries have formal mechanisms for the broader process of technology assessment (Porter 1995), except in specific sectors such as pharmaceuticals (Meek & Hughes 1995). One issue raised repeatedly by NGOs in project-scale EIA of uranium mines, for example, is that the EA considers only the individual mine, and there is no mechanism for public SEA of nuclear technologies as a whole.

Sectoral SEA

SEA of entire industry sectors within a particular country is now used extensively by bilateral and multilateral aid, loan, and finance institutions, notably the World Bank (1992, 1993), and is proving to be a very useful planning tool, both nationally and internationally (Day and Quinn 1991; Thompson, Treweek, and Thurling 1995). It is also used by some large corporations and governments for long-term planning (Commission of the European Communities (CEC) 1993; Azzone & Bertele 1994; Hutchison 1996). The advantages of sectoral SEA (World Bank 1993) are similar to those of project EIA, but at a sectoral scale:

- prevention of serious environmental impacts at a sector-wide scale
- increased transparency of sectoral planning
- improved analysis of institutional frameworks within the sector concerned
- consideration of alternatives at the sectoral policy scale
- elimination of unsound investment alternatives for the sector
- inclusion of cumulative impacts in assessment
- identification of gaps in environmental baseline information
- sector-wide environmental mitigation
- improved cooperation between sectoral agencies
- expediting environmental planning for projects in that sector.

The World Bank's *Environmental Assessment Sourcebook* (1992) contains guidelines and sample terms of reference for:

- twelve types of agricultural and rural development projects, such as dams and fisheries, irrigation, and agrochemicals
- ten types of infrastructure development, such as roads and ports, water supply and waste management, housing, and tourism
- twenty types of energy and industrial development projects, such as pipelines and power lines; power plants, chemical plants and cement plants; and food processing, timber processing, and mineral processing.

Case studies of sectoral SEA include the central Indian coalfields (Buckley 1988), the Pakistan national drainage program, the Nigerian national highway program, and pan-African locust control program (World Bank 1992). Sixteen more are listed in the *Sectoral Assessment Update* (World Bank 1993): five in transport, four in agriculture, five in water supply, sanitation, and waste management, four in energy and power, and one in the mineral industries.

Generic Project EA

Generic project EA was trialed a decade or more ago in a number of countries and industries, but has largely been overtaken by other approaches. No two projects, ecosystems or jurisdictions are quite the same, so each project needs a new EA at least in part. Where a new project is similar to one or more previous projects, the proponent or consultant for the later one should in any event routinely consult EA documents for the earlier ones, and use relevant material as appropriate. Commonly, however, even for very similar projects, new research during the intervening period renders the old EA outdated. A more effective approach, and one in common use at present, is to construct generic scoping checklists for particular types of development and particular types of environment, and combine them as required for individual development proposals. This is essentially the approach used by the World Bank (1992) in its sectoral EA guidelines and draft terms of reference. Many countries have also produced generic guidelines for project-scale EIA in different sectors (Roe, Dalal-Clayton, and Hughes 1995).

Conclusions

SEA is a very important but much-neglected form of EA. Without the various forms of SEA, the potential for project-scale EA to contribute to sustainable development is greatly weakened.

There are several potential reasons why SEA has not been widely adopted to date, but none is sufficiently compelling to prevent SEA being widely adopted in the future. SEA is technically more difficult than project-scale EA, but it is still perfectly feasible. There is no legal framework for SEA in most countries; but there easily could be; and where there is, it is not being used. There is no funding mechanism either, but again, there easily could be.

If governments and electorates actually are concerned that development should be sustainable, then SEA, particularly at a policy level, is an urgent and essential step in that direction.

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9

Strategic Environmental Assessment (SEA)

Robert Goodland[1]

Abstract

Project-level environmental assessment (EA), while remaining essential, cannot help in the important decisions of project selection. Therefore, it needs to be complemented with strategic EA (SEA). Reactive project EA is transformed into proactive SEA. SEA is EA applied above the project level. SEA commonly is applied to whole sectors, thus aiding in the selection of projects. Sectoral EA integrates social and environmental criteria into conventional least-cost economic sequencing of projects in a sector. SEA also should be applied to programs, draft treaties, privatization, national budgets, and legislation.

Key Words: environmental assessment, impact assessment, sectoral assessment, strategic assessment, environmental sustainability.

Introduction

This paper presents the case that today's project-level environmental assessment (EA) needs to be extended "upstream" into strategic EA (SEA).

- EAs of entire sectors, such as the power sector or the transportation sector, need to be completed preferably before selecting the next project in that sector. This is the role of Sectoral EA, a subset of Strategic EA.
- EAs need to be used in policy and program formulation, such as in designing structural adjustment or in policy-based lending. EAs also should be used in national priority-setting exercises, such as the national budgeting process and in national approaches to environmental sustainability. EA of policies, programs, national budgets, legislation, and international treaties—"Strategic EA"—is the focus of this paper.

Why Strengthen Current EA?

Current project-level EA is becoming successful in improving the design of individual projects. Improving individual projects will continue to be necessary, and project-level EA should be strengthened. But we now see that project-level EA, while increasingly necessary, is insufficient to improve economic development in developing countries up to any notion of acceptability. The world has changed greatly since EA began a quarter of a century ago. Environmental quality has deteriorated in so many parts of the world that piecemeal project-by-project approaches of conventional EA no longer suffice to ensure prudent environmental standards. As development moves from financing primarily infrastructure into combining that with purveying advice in national economic dialogues, the environmental implications of policies become more important than that of individual projects.

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Traditional Reactive EA

1. Project-level EA
2. Regional EA
3. Cumulative EA

Strategic Proactive EA

4. EA of Sectors
5. EA of Programs and Policies
6. EA of Structural Adjustment
7. EA of Privatization
8. EA of International Treaties
9. EA of National Budgets

Figure 1: A Typology of Environmental Assessment

Strategic EA

Strategic EA is defined as "the formalized, systematic and comprehensive process of evaluating the environmental impacts of a policy, plan or program and its alternatives, the preparation of a written report on the findings, and the use of the findings in publicly-accountable decision making" (Therivel et al. 1992).

Traditional reactive project level EA is necessary but not sufficient to exploit opportunities which exist today but which may be gone tomorrow. Reactive project-level EA must be transformed into proactive or strategic EA. SEA improves investments over the long term and should be fed by long-term projections. Thus, Strategic EA is a process by which environmental implications are integrated into decision making above the project level. SEA extends EA into non-traditional areas such as entire sectors, policies and programs. Sectoral EAs are a subset of strategic EAs which started almost a decade ago to great effect. Strategic EA has started internationally, and has been used most successfully in water supply, civil aviation, power supply, and waste disposal (Wilson 1993).

Strategic EAs, those which look at programs, policies, treaties and other non-traditional areas, are the newest style of EA work. Strategic EA is the application of EA above the project level. Although already promulgated by the EC and several countries, and although provided for by the U.S. NEPA (National Environmental Policy Act), SEAs are still not yet routine. During the decades of development of trade agreements between the U.S. and Canada, the treaty was not subject to EA procedures. The SEA trend has started well in extending environmental analysis into whole economies, rather than into a single project.

Sectoral EA

Sectoral EA, the most common form of Strategic EA, is the process of examining potential environmental and social implications of all or most of the potential projects proposed for the same sector. Sectoral EA influences project selection, which project-level EA almost entirely cannot. Sectoral EAs provide an environmental ranking of all proposed projects in one sector before pre-feasibility, and helps decide in project selection (e.g., gas *vs* coal *vs* hydro *vs* nuclear energy in the power sector; or road *vs* rail *vs* air in the transport sector).

Sectoral EA begins with a development objective or goal and then evaluates the numerous possibilities of meeting agreed on results. Instead of beginning with, say, a pre-conceived proposal of a 200 MW coal-fired power plant at spot “x” on the map, a sectoral EA would begin with the premise of meeting projected power needs by optimal methods, including energy conservation and development of renewable energy. Sectoral EAs reduce the costs of subsequent project-level EAs, but do not obviate the need for them. Sectoral EAs have started to be used, especially in improving traditional least-cost economic analyses into economic, social, and environmental least-cost sequences (World Bank 1993). Power sector expansion sequences increasingly have environmental and social rankings alongside the conventional economic ranking, and this constitutes a form of Sectoral EA. Sectoral EAs are most frequent in the power sector (e.g., Ventura Filho 1995 for Brazil; Meier and Munasinghe 1994 for Sri Lanka), less so in transport modal choice, and rare thus far in the agricultural sector. The most recent case in which SEA is used in the transport sector is in Brazil’s southern region in which IAIA’s Brazil chapter has been contracted to undertake the SEA in a World Bank-assisted project.

The value of Sectoral EA is to gather existing data and examine it to detect gaps in time to start collecting data required to make informed decisions about the selection of the next project in the sector. Sectoral EA makes project-specific EAs much faster, cheaper, and more sound because data are already assembled into information management systems and data gaps are already identified. The great power of Sectoral EA is that it helps rank potential projects in an environmental sequence, so that environmentally better projects are taken up before environmentally weaker projects. Environmental ranking of all potential projects exposes society to tradeoffs. The ranking itself should largely be as a result of participation by civil society. By such rankings, SEA fosters transparency into long-range plans. This helps promote acceptance by taxpayers and affected people. It also decreases the likelihood of purely political decisions. “Pork barrel” selection of a project in a politician’s home area is less likely because it becomes clear that better or cheaper sites or technologies are available elsewhere.

For example, if an EA team conducts an EA on a nuclear power plant, the team should first explore the possibility that demand management may reduce demand enough to allow postponement of the need to increase capacity. Secondly, the team should determine if other generation alternatives are economically and environmentally feasible, such as hydro or natural gas. As a general rule, the power sector has long-term least-cost sequence plans which sometimes include environmental considerations, such as human involuntary resettlement and wildlands, but these often get lost in the hurry to complete engineering and economic analyses. These environmental and social costs then re-emerge after heavy expenditures on detailed engineering have been completed and the proposed project has become more firmly entrenched in national development plans. Sectoral EAs should identify the real options at a stage before expenditures for design have become too great.

If a good EA team is asked to assess the impacts of a new highway, they may well recommend a railroad, not a highway. Such a response would not please the National Highway Authority which requested the highway EA and would likely result in dismissal of the EA team. This might not be the best course for the environment or the nation.

Strategic EA of Treaties

Can EAs influence draft international treaties such as GATT, NAFTA, FCCC, UN Montreal Protocol, and the UN Biodiversity Convention? The U.S. NEPA specifically provides for this. However, in the main case since then, the courts ruled that EA should not be applied to the NAFTA treaty while still in draft. But then, when the NAFTA treaty was in near final form, the courts ruled it was too late! In 1993, the U.S. Supreme Court ruled that the Clinton administration was not required to comply with NEPA in the case of the trinational North American Free Trade Agreement (NAFTA), because it was an action of the President. However, the administration voluntarily completed environmental analyses of NAFTA (USA 1993), although not in compliance with NEPA procedures. A similar report was prepared for GATT (U.S. Trade Representative 1994). These encouraging assessments show that SEA can and has been performed effectively on international treaties.

Strategic EA of Privatization

Privatization is sweeping the world, almost as dogma. While it may have economic benefits, the environmental and social costs need to be determined in advance. Privatization has massive environmental and social implications which should be subjected to rigorous SEA. The typical pattern today is that governments seek to prevent the worst environmental impacts of their investments. To this end, nearly all governments have set up their own environmental ministry or agency and, except in Sub-Saharan Africa, they have made EA mandatory. This approach has started to work, although much remains to be done.

Now governments are relinquishing major sectors of the economy to the private sector. Clearly, the capacity of government to regulate the private sector will be critical in this transition. Government capacity is barely adequate today for its own (governmental) investments. This is because one governmental agency has great difficulty in getting another government agency to increase expenditures for environmental needs. When a sector is privatized, the government can optimistically require the private sector to meet national environmental standards, and the private sector can raise charges to do so. Government capacity should be in a position to regulate and monitor the private sector, especially when dealing with multinational corporations with operating budgets larger than many developing country GNPs. Environmental and social capacity strengthening of governments is an essential pre-condition to privatization in environment-sensitive sectors.

Strategic EA at the National Level

Environmental Assessment of National Budgets

The national budget is arguably the most important statement of environmental priorities that any government ever makes. At least at a superficial level, it is relatively easy to identify anti-environmental expenditures in a budget. The most detailed analysis of any national budget so far is that of the U.S. federal budget by Friends of the Earth (FOE) (de Gennaro and Kripke 1993). Friends of the Earth's "Green Scissors" Report (FOE 1995) shows how to cut environmentally harmful expenditures.

The first need is a systematic EA of the budget to seek to reduce financing damage. Subsidies to federal grazing, mining, water, and timber are the main examples of anti-environmental budget expenditures. Tax breaks for oil drilling means the oil industry is spreading its own private risk across the public, which does not equally participate in any future profits. Subsidies and other inducements to civilian nuclear power are strongly asymmetrical at best. About 75% of total research and development expenditures has been consumed by the nuclear industry over the last four decades, although it generates about 3% of global commercial energy.

The second need is to identify the pro-environmental expenditures in the budget and compare them with other expenditures to force taxpayers to ask if those are the priorities for which they voted. For example, the new (c. 1995) UN "20/20" goal is that: if 20% of a developing country's budget is allocated to social expenditures, it will be matched by 20% of international development assistance. The social side of the assessment will address the employment implications of the budget proposals. Fortunately, more environmental attention almost always increases employment, rather than reduces it.

Internalization of Environmental Externalities for Sustainability

The most direct way to approach sustainability of both project-level EA and SEA is to internalize all environmental externalities. Not to do so is the root cause of most environmental damage today, as well as much damage to human health. The World Bank formally adopted sustainability as a policy in 1984. Environmental assessment reduces potential impact on sources and sinks, therefore it becomes the main tool fostering sustainability in project level investments. We suggest that this approach now be applied to promote sustainability in the policy arena. The Treaty on European Union mandates sustainability (article 130u) and the internalization of environmental externalities (article 130r2) as emphasized in its Sustainability Treaty of Parties (Article 130r3; Commission of the European Countries (CEC) 1992). In the large areas where economic costs cannot yet be calculated, surrogates or estimates (e.g., shadow price of restoration) are to be applied because the default value is certainly greater than zero. The CEC Treaty even goes so far as to mandate the use of "....an appropriate discount rate which safeguards the rights of future generations with due allowance for uncertainties and risk."

The economic analysis of projects in development agencies needs to reflect more systematically any direct linkages between the environmental analysis and the economic analysis. The mitigation program devised from the EA is not always fully integrated into the overall total project costs. As the costs of implementing the mitigation plan rarely exceed 10% of total project costs, the economic rate of return does not change and a separate environmental C/B analysis is not undertaken. The economic analysis of projects should systematically reflect the costs of the environmental impacts identified in the EA, or the full costs of mitigating all impacts.

- Mitigation plans deal mainly with "traditional" environmental costs and often err in underestimating such costs.
- Resettlement costs almost always exceed initial estimates substantially, and in most cases the oustees are not as well off after the project.
- Pneumoconiosis, silicosis, "black-lung" disease, SOx, and NOx have only fairly recently been included in coal-thermal projects.
- CO_2 costs are still normally externalized in coal-thermal projects.
- The benefits of downstream replenishment of soil fertility by annual flooding is normally excluded in reservoir projects.

Figure 2. Case Example - Internalizing Negative Environmental Externalities in Energy Projects

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Life-Style Changes for Sustainability

EAs rarely recommend lifestyle changes, although these may be necessary to achieve any semblance of sustainability in the long run. EAs for projects in countries with high population growth rates, for example, never point out the imprudence of investments to increase the supply of electricity, housing, schools, transport, or food unless population stability is actively promoted in parallel. For example, many more people could be well fed on the UN "Grain-Based" Diet, and be much healthier, and at much lower environmental and social costs than on meat-rich diets, yet this is never raised in EAs. Promotion of organic farming and phasing out of fertilizer and biocide subsidies would be enormously effective in reducing pollution and the environmental costs of extensification. The necessary tripling of food production over the next fifty years has massive environmental implications which must be carefully assessed in advance.

SEA of Global Issues

Historically, EAs have been applied to individual projects and almost entirely to national environmental impacts. Only occasionally have binational impacts been addressed. The most common example is downstream riparians affected by upstream water projects. But now that many environmental impacts have grown to global proportions, clearly a global approach is necessary to tackle them. This is mandated, but not yet achieved, under World Bank's policy (OD 10.04). This would be in addition to measures to tackle individual contributors to such impacts at the national level.

Global environmental issues are an area where there has been more progress by UN treaties than in other areas. The Montreal Protocol to stabilize damage to the ozone shield, the Biodiversity Convention to slow or halt species extinctions, and the UN Framework Convention on Climatic Change (FCCC) to stabilize climates are examples where good science is being applied to accelerate political improvements. These three instruments are also powerful means to move towards global sustainability. The basis of these treaties is stability, and stability is an important component of sustainability whether in tropical timber, human population, GHG emissions, or CFCs.

Stability in species numbers is not a specific goal of the UN Biodiversity Convention. The Convention mentions the vague goals of "conservation of biodiversity and the sustainable use of its components."[2] But if zero anthropologically caused species extinctions is not a goal of the Biodiversity Convention, who is to say which species and how many species can be extinguished? Although there seems to be much built-in redundancy in species numbers in certain taxa ("there is an inordinate number of beetles"), not enough is known to be able to say with acceptable risk that we can get along without species *x* or *y*. Furthermore, it is difficult if not impossible to achieve the extinction of only one species, particularly in complex interrelated tropical ecosystems. How much of the biosphere should be appropriated by the human species, and how much should be conserved for all other species? Although stability (of humans, species, atmospheric composition) is an essential precondition for any notion of sustainability, it is insufficient.

The case of the UN Climate Change Convention is more commendable. More than 167 nations have signed this international treaty and 125 have ratified it. This is a tremendous recognition of the problem. Clearly, big oil exporters would suffer if they become unable to export their major, sometimes their only asset, therefore they are understandably less than enthusiastic about endorsing the treaty. How can the world community protect such economies? The world community has started to compensate species-rich tropical forest-owning countries; should similar mechanisms be envisaged for fossil fuel-owning nations? Strategic EA can help provide answers. The big coal-containing countries, potentially even more damaging than oil burning, may have started to realize that the world cannot afford to burn its estimated 300 years of coal reserves. The natural gas owning countries subscribe to the FCCC because any transition to gas away from wood, coal, and oil is good for the environment, and, in any event, the gas will be essentially all burned within possibly fifty years. The FCCC proposes to halt current damage and then to revert to an earlier, safer state; namely, to revert to 1990 emission levels by 2000.

The FCCC does not yet accept that a phase-out of coal is essential for climatic stability. As the world still has more than 300 years of coal left, its phase-out must occur long before its exhaustion. Most remaining fossil fuels will have to be left in the ground: a premonition of "absurdly strong sustainability" (Goodland 1995).The FCCC does not overtly publicize that a transition to renewable energy will be essential for climatic stability and sustainability. Those countries responsible for nearly all the damage to date, namely OECD, are mandated to act first in reducing their emissions. But the source of most future emissions, developing countries, still are exempt from any commitment to halt their emissions. The FCCC responsibility for LDCs (least developed countries) is limited mainly to paper reports. For example, LDCs should report on their emissions annually, and should draw up plans for rational energy and transport expansion.

The Montreal Protocol

The main impacts of ozone depleting substances (ODS) seem to be:

- Increasing skin cancer (up 25% by 2050 in midlatitudes) severely increases health costs of Canada, New Zealand, Australia, and elsewhere.
- Damage to human immune systems compromises vaccinations and weakens ability to fight infections.
- The possible annual loss of up to seven million tons of fish. UVb light damages phytoplankton, the basis of the oceanic food chain. Krill also is threatened.
- UVb light damages germinating or sprouting plants, including crops.

The speed of phase-out of ODS leaves much to be desired. When the two main CFC producers have managed to develop economic alternatives of benefit to them, it is not a prudent criterion on which to base phase-out of globally damaging substances. The EU has adopted the year 2015 to phase out HCFCs; this is dangerously lax. One nation, Luxembourg, has banned HCFC use already. Permissible chlorine levels seem to be riskily generous. SEA would weigh the environmental costs and benefits (especially health) to help decide on the optimal ODS phase-out rate. It is clear that environmental assessment needs to be much more a part of UN Treaty formulation.

Conclusion

Project-level EA needs to be continued and strengthened. In particular, it must influence project design.

Regional EA and cumulative EA processes should continue to be strengthened and used more frequently.

Sectoral EA phase-in should be accelerated in order to reduce the cost and increase the effectiveness of the benefits of project-level EA. Sectoral EA is a powerful tool to help in project selection, and improves economic C/B analysis.

*Strategic EA***,** in general, should be more systematically applied to:

- Structural adjustment, privatization, transnational corporations, macro-economic work and "green" SNA.
- National budgets, NEAPs, and national-level policies and programs.
- Environmental sustainability and the internalization of externalities.
- Global issues and international treaties such as climate change, biodiversity, and ozone-shield protection.
- All EA legislation, regulations, and procedures should address social EA, whether integrated with biophysical EA or separated.

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[2] Article 8(h) : "*In situ* Conservation" On the contrary, one of the few places where species are specifically mentioned provides for the *eradication* of alien species. One could argue that if biodiversity and natural habitats are conserved, then species extinction will cease. But that is nowhere stated as the goal. Therefore the convention seems to aim at slowing the extinction rate. That would be better than today's fast extinction rates, but there is no guidance on how slow the extinction rate should be.

This paper should in no way be construed as the official position of the World Bank Group.

10

Cumulative Environmental Impacts

Ralf Buckley[1]

Abstract

Most human impacts on the natural environment act cumulatively, but few EA (environmental assessment) frameworks assess cumulative impacts adequately. Cumulative impacts range from simple additions to prior impacts of similar type, to complex interactions of environmental stresses due to the multiple impacts of many different types of development. For EIA (environmental impact assessment) to be effective, cumulative impacts must be considered at all stages in EIA. Currently, the greatest deficiencies are at the triggering and decision-making stages, which are legal and political, rather than impact assessment itself, which is technical.

Key Words: EIA cumulative impacts, triggering, legislation, benchmark

Introduction

EIA means assessing the impacts of human activities on the physical, biological, and human environment. EIA is a core component of planning and development law in most industrialized nations. Human impacts, however, rarely act independently on the physical and biological environment. If two chemicals are discharged into a waterbody, and they don't react either with each other or with the same third compound, then their resulting concentrations may be largely independent. For aquatic organisms in that waterbody, however, the effect of discharging both chemicals simultaneously will generally not be equal to the sum of the effects of discharging each separately. Similarly, the effects of two separate equal discharges of heated cooling water will rarely be twice the effect of only one discharge.

Cumulative effects, therefore, are the rule rather than the exception; and this applies whether the impacts concerned derive from the same or different developments. In most nations, however, EIA and planning law treat cumulative impacts very differently if they are from several separate activities or developments, requiring separate approvals, than if they are from a single development requiring a single approval.

Thus while EIA law is based in principle on ecological processes, it does not reflect them in practice. This issue has been recognized for many years, and there have been various past and current attempts to improve the assessment of cumulative impacts in EIA and planning law (Buckley 1989, 1994, Vanclay and Bronstein 1995).

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Types

Cumulative environmental impacts may include the following issues:

- marginal environmental impacts of new development in an area with prior impacts
- total aggregate environmental impacts of multiple developments in a defined area
- overall impacts of many similar concurrent developments in a defined area
- interactive impacts from nearby developments of different types
- interactions between impacts from diffuse and point sources
- increases in impacts over time, from growth in existing activities
- joint net impacts of multiple developments on particular environmental parameters, such as air or water quality
- joint effects of multiple stresses on plant and animal populations; e.g. through habitat clearance, crowding, noise, air and water pollution, pathogens, etc.

Scale

In practice, assessment of cumulative impacts is especially important at intermediate development scales. Potential environmental impacts of major new greenfields development projects are assessed under EIA law at state and federal levels in most countries. Multiple small development projects, such as new residential houses, are controlled by local government planning law. For intermediate numbers of developments at intermediate scale, however, such as in coastal tourism development, the individual developments may not be large enough to trigger EIA processes, even though aggregate impacts may exceed those of a single large development. Although EIA guidelines often mention cumulative impacts, legal frameworks for development approvals generally only consider marginal impacts associated with particular development applications. For a series of intermediate-scale developments, therefore, each new development application is effectively assessed against a different baseline. Legal as well as technical mechanisms are therefore needed to ensure that cumulative impacts are considered in assessing development applications (Buckley 1992a; Warnken and Buckley 1995, 1996).

There may also be instances where the scale of particular development applications has been reduced so that local planning authorities can approve them without public EIA; and then increased again through a series of modifications which can also be approved without public EIA. A similar mechanism is needed to ensure that such modifications are considered cumulatively with the original application in determining whether EIA requirements are triggered. (Note that this refers to multi-stage development applications, which are quite different from multi-phase EIA.) (Buckley 1992b).

Frameworks

Over longer timescales, broader questions of community and individual rights become significant. Landowners in a small coastal community, for example, may not object to hotels and other tourist developments initially, but may object to new developments once their lifestyles are affected by cumulative impacts on the natural or social environment. Proponents of the most recent development proposals, however, may argue that they should have the same development rights as their predecessors. In such cases it is not the technical issue of assessing cumulative impacts which is at stake, but the legal issue of property rights, and the political issue of community conflicts.

To incorporate cumulative impacts into EIA and planning processes therefore requires:

- techniques to identify, assess, predict, quantify, and manage cumulative impacts
- legal or administrative mechanisms to trigger cumulative impact assessment
- policy decisions as to how cumulative impacts are to be treated in planning
- economic measures for equitable distribution of costs

From a purely technical perspective, assessment of cumulative impacts is generally quite feasible with current expertise. There is a considerable body of relevant experience worldwide, and an extensive literature on techniques and outcomes from the 1980s onward (Buckley 1994).

As noted above, if two or more separate primary impacts from a single development are expected to have synergistic secondary effects, this is already assessed under current EIA processes. The issue is to apply relevant techniques to assessment of impacts cumulative between separate developments. From a policy perspective, cumulative impacts need to be included at three distinct stages of EIA processes:

- triggering the requirement for EIA
- preparation of EIA documents
- planning decisions based on EIA documents

Triggering

The first requirement is that if the likely marginal impacts of a proposed development would not exceed the threshold needed to trigger a particular level of EIA, but the likely cumulative impacts of that development together with prior existing developments or other concurrent proposals would exceed that threshold, then EIA processes should in fact be triggered at that level.

There are two main approaches. One is to compare the total predicted impacts of a particular development proposal, including all cumulative components, with the best estimate of baseline conditions before any development commenced at all. Single-project EISs often already include estimates of plant and animal communities and air and water quality before any modern development, as well as details of their status prior to the development currently proposed.

The alternative is to compare the predicted state of the environment, once modified by the likely impacts of the development proposal under consideration, with some predefined benchmark or ambient standard. The benchmark itself, of course, effectively represents a limit of acceptable change from the original pre-development baseline. Again, single-project EISs commonly compare predicted impacts with current standards for particular environmental parameters, e.g. in air and water quality. In most jurisdictions, however, these standards are generally set in marginal rather than cumulative terms: i.e., as emission rather than ambient standards, in the case of air and water quality. From a policy perspective, considering cumulative rather than marginal impacts hence requires a shift to ambient standards. Such standards are already in limited use in some countries, but not others. Regulations controlling noise, or emissions into some closed waterbodies, provide common examples.

Assessment

The second policy requirement is that when EISs or equivalent documents are being prepared, they should consider cumulative impacts. In principle this is straightforward, and many jurisdictions already specify this requirement in legislation, administrative guidelines, or scoping documents. Cumulative impact assessment has been required through the Cluster Impact Assessment Procedure under the U.S. National Environmental Policy Act (NEPA) for many years, for example (Smit and Spaling 1995; Hunsaker, this volume). In practice, however, most EIA documents generally give only cursory attention to impacts cumulative with those of other developments. This is probably because government agencies responsible for assessing EIA documents, and any legal tests for the adequacy of such documents (Buckley 1991a), do not currently give much weight to impacts of that type.

Decisions

The third policy issue is as follows: once potential cumulative impacts have triggered EIA processes and actually been considered in EIA, how should they be treated in determining the outcome of planning and development applications? The critical issue is the relative weight given to marginal impacts from the development proposed, compared to impacts from other prior or concurrent developments. In pollution control, for example, emission standards effectively give the latter zero weight relative to the former, whereas ambient standards give them equal weight. An intermediate weighting would clearly also be possible. This would effectively apply a different baseline for later development applicants than for their predecessors. If cumulative impacts are to be considered at all, then the weighting must be greater than zero. To prevent incremental attrition of environmental quality, it should be unity. In actual development approvals of most nations, it has typically been less than one: impacts from prior development are taken into account, but only with subsidiary emphasis.

An alternative approach, which again is already in limited use in many countries, is to establish tradeable development or environmental property rights with a fixed cumulative total (Buckley 1991b). In areas where total rights are already exhausted, applicants for new developments must either purchase development rights from an existing holder, or gain development credits through environmental improvement at another site in the area. The concept is straightforward, but the application is not. The critical issues are (1) bundling and separability of rights relating to different environmental parameters, (2) bottlenecks and limiting resources, and (3) cross-parameter transferability.

Can a corporation acquire a single right entitling it to build a manufacturing plant of a particular type, for example, or must it acquire separate rights to remove soil, clear vegetation, reduce animal populations, discharge a suite of individual substances to air and water, and dispose of solid waste in landfill? If the former is the case, then there is unlikely to be a competitive clearing market in the rights concerned, except for very common types of development such as residential housing. If the latter, then individual developments will typically be constrained by the proponents' ability to acquire rights in regard to particular limiting environmental parameters. This is logical enough from an environmental management perspective, and does indeed occur in areas where tradeable environmental rights are used: air emission rights in the U.S., for example. And can a corporation acquire rights in respect of one environmental parameter by establishing credits in respect of another, or not?

Uncertainty

For all of the approaches outlined above, there is the additional issue of uncertainty. There are uncertainties in predicting impacts from particular developments; in predicting developments likely to occur in future; in predicting the effect of new impacts on ambient environmental quality; in predicting secondary impacts and interactive effects; and so on.

Conclusion

All of these issues and approaches are relevant irrespective of whether cumulative impacts are included in EIA and planning processes, but become more significant if they are. In general, if cumulative impacts are not included, development decisions can be made without necessarily considering these issues. If cumulative impacts are included, then these issues are unavoidable.

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11

Cumulative Effects Assessment[1]

Carolyn T. Hunsaker[2]

Abstract

Cumulative impacts are the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions. Excellent reviews and extensive literature exist on cumulative impacts—what they are, how their effects can be assessed, and how they can be managed. However, quantitative assessments of cumulative effects will continue to be difficult until we have additional quantitative tools to use with designed and consistent long-term monitoring. The importance of cumulative effects assessment to sustainable development is discussed.

Key Words: cumulative effects, cumulative impacts, assessment framework, landscape ecology, risk assessment

Introduction and Historic Background

Cumulative impacts on ecosystems are a function of increasing numbers of humans and their associated activities per unit area. As impacts continue to increase, the ability to sustain a desired condition for humans and other species becomes questionable. In the U.S., the implementing regulations of the National Environmental Policy Act (NEPA) define cumulative impacts as "the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions..." [40 C.F.R. Sect.1508.7 (1978)]. Dickert and Tuttle (1985) provide a somewhat more detailed definition:

> ...cumulative impacts are those that result from the interactions of many incremental activities, each of which may have an insignificant effect when viewed alone, but which become cumulatively significant when seen in the aggregate. Cumulative effects may interact in an additive or a synergistic way, may occur onsite or offsite, may have short-term or long-term effects, and may appear soon after disturbance or be delayed.

Researchers in Canada and the U.S. have published excellent definitions and discussions of cumulative impacts and associated issues (Canadian Environmental Assessment Research Council and U.S. National Research Council 1986; Peterson et al. 1987). The U.S. Fish and Wildlife Service was one of the first federal agencies to work on develop-

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ing an assessment protocol (Williamson et al. 1986). Very early the U.S. Environmental Protection Agency (EPA) supported research into cumulative effects in wetland ecosystems. Bedford and Preston (1988) synthesized concepts from an excellent collection of papers on wetlands; this was followed by the work of Liebowitz et al. (1992). Although not without problems, the Federal Energy Regulatory Commission's (FERC's) cumulative impact assessments and subsequent management of hydropower permits probably constitute the most extensive example of cumulative impact work within a U.S. federal agency. FERC's efforts include both a policy and numerous examples of its implementation (FERC 1985a; FERC 1985b; Cada and Hunsaker 1990; Irving and Bain 1993). Since 1978, the implementing regulation for NEPA required assessment of potential cumulative effects, and many of the states' "mini-NEPAs" also have such requirements.

Extensive literature exists on cumulative impacts—what they are, how their effects can be assessed or evaluated, and how they can be managed (e.g., Bedford and Preston 1988; Williamson and Hamilton 1989; Irwin and Rodes 1992; Hildebrand and Cannon 1993; Douglas, Fuchs, and Lester 1995). Despite the long-time recognition of this phenomenon and a substantial literature that addresses it, we have not been particularly effective at assessing or managing cumulative impacts. Better interaction between the natural and social scientists and policy-makers is necessary and should improve our ability to manage cumulative impacts. In addition, the assessment and management of cumulative impacts has to occur at all levels—local, regional, and national, and it has to be an interactive and ongoing process. Douglas, Fuchs, and Lester (1995) provide an excellent overview of works relevant to cumulative impacts, and Irwin and Rodes (1992) present a review of requirements for cumulative impacts in U.S. statutes and definitions of cumulative impacts.

Conceptual Developments

Frameworks provide a useful construct for the thought processes and work needed to accomplish any assessment. Two general frameworks are especially relevant to cumulative impact assessments. Irwin and Rodes (1992) present an unique framework developed to help identify the mismatch between the boundaries for management and the boundaries that define a cumulative impact. Crafted by scientists and policy-makers actively involved in cumulative impact assessment, the framework provides program managers with a means of comparing the boundaries of management decisions with the boundaries of cumulative effects and their causes. On the basis of this comparison, managers should be able to determine whether a mismatch occurs and, if so, find ways to use more appropriate boundaries. A set of questions, discussions, and examples are provided to walk one through each step of the framework.

Ecological risk assessment, especially when applied at the regional scale (Hunsaker et al. 1990; Hunsaker 1993), is the second framework relevant to cumulative impact assessments. The objective of risk-based ecological assessment is to provide a quantitative basis for comparing and balancing risks associated with environmental hazards. Risk assessment is distinguished from other assessments, in that it provides a systematic means of improving the estimation and understanding of those risks and it explicitly recognizes and quantifies uncertainty about the risks. Components of the risk assessment framework include problem formulation; analysis (i.e., characterization of exposure and characterization of ecological effects); data acquisition, verification, and monitoring; and risk characterization. Cumulative impacts are best addressed at the regional scale because it is at this spatial scale and associated temporal scales that the majority of cumulative effects will manifest themselves (Hunsaker 1993). Because the availability of data and models, as well as time and/or money, will constrain the completeness of the assessment, following the structured problem formulation phase of risk assessment (Risk Assessment Forum 1992) should help ensure a successful assessment of cumulative effects. During problem formulation the goals, breadth, and focus of the assessment are established, and the conceptual model is developed, including the stressors, endpoints, and spatial/temporal boundaries. Finally, because risk assessments include uncertainty or confidence estimates throughout the process, during the problem formulation phase the assessor may better focus on those stressors and endpoints that seem most critical and tractable for assessment. Furthermore, the inclusion of uncertainty in cumulative impact assessments should assist the risk manager in making policy or management decisions, which usually require trade-offs to curtail cumulative effects.

The framework of Irwin and Rodes (1992) is complementary to risk assessment frameworks (Hunsaker et al. 1990; Risk Assessment Forum 1992). The first assists managers in understanding why cumulative effects are occurring, the latter in quantifying those impacts. The separate frameworks highlight the important fact that assessment and management of cumulative effects are separate but linked activities.

Applications and Techniques for Assessing Cumulative lmpacts

Shopley and Fuggle (1984) and Hunsaker and Williamson (1992) provide reviews of techniques for assessing cumulative impacts. Assessment techniques can be divided into those used for problem definition and those used for analysis and interpretation, two of the phases illustrated in EPA's ecological risk assessment framework. Ad hoc techniques, checklists, and matrices are often used for the problem definition phase. Techniques used in the analysis and interpretation phase include network or system diagrams, cartographic techniques, mathematical modeling, evaluation techniques, and adaptive methods or combinations. Weaknesses in assessment techniques consist of inability to quantify effects, especially at the ecosystem scale, lack of interactive or coupled models, and lack of models that can deal with multiple media and stresses.

Concepts developing in the discipline of landscape ecology hold promise for helping with cumulative impact assessments, and several publications illustrate the importance of a landscape ecology approach (Bedford and Preston 1988; Hunsaker et al. 1990; Gosselink et al. 1990) to evaluating cumulative effects. A landscape can be defined in terms of the following:

- structure—the spatial relationships between distinct elements
- function—interactions between spatial elements
- change—temporal alterations in the structure and function of the landscape mosaic.

Landscape ecology is the study of the distribution patterns of communities and ecosystems, the ecological processes that affect those patterns, and changes in pattern and process over time (Forman and Godron 1986). The study of scale, both spatial and temporal, is a major part of landscape ecology, and a better understanding of scale issues is critical for cumulative effects assessments (Hunsaker 1993).

Assessment and management of cumulative impacts in the coastal zone has always presented a special challenge; the Coastal Zone Management Act was established in 1972. Integrated coastal zone planning at local and regional scales, fishery and habitat management goals, and statements about desired ecosystem condition (like sustainability) can provide a long-term context for marine systems that is consistent with societal values (see Reiser and Vestel 1995 for recent direction about cumulative effects assessment for marine systems). The National Research Council recently held a series of workshops that addressed many relevant issues for cumulative impacts (National Research Council 1995).

Recommendations for Improving Cumulative Impact Assessment and Management

Many ideas have been discussed in the literature about how we can improve cumulative impact assessment, but only when assessment and management activities work together can we hope to be effective in understanding and controlling cumulative effects. Brief synopses of three recent papers capture the essence of what we need to work on for improvement. Contant and Wiggins (1993) identified the following three areas to improve assessments:

- improving monitoring and prediction of actions and impacts over space and time
- increasing the knowledge of the responses of environmental systems to development perturbations, including synergistic and indirect effects
- developing management systems that provide the appropriate responses to actions that produce significant cumulative effects.

Williamson (1993) stresses the importance of remembering that an assessment is a process: "...employ a problem-solving process that can be applied intensively to a wide range of situations and that utilizes adaptively the most appropriate methods and techniques." He states that, to be effective, a cumulative impact assessment must use both a problem-solving process and scientific cause and effect, while cumulative impact management must use both goal setting and collaboration. In highlighting the need for a common language among scientists and policymakers, Douglas, Fuchs, and Lester (1995) state that our institutional capacities are inadequate to manage cumulative impacts because of fragmented, incremental decision making. In other words, we need to design a new way of business. With regard to the need to integrate science and policy, Douglas, Fuchs, and Lester (1995) identify the following issues:

- management goals and research priorities
- identification of methods, indicators, and causal models for evaluation of cumulative impacts
- design of monitoring programs
- design and maintenance of databases and information management systems.

Although NEPA legislation was effective in bringing both attention and efforts to bear on cumulative impacts, it has not provided an especially effective way of truly managing them except, perhaps, when a programmatic environmental impact statement (EIS) is being done (Cada and Hunsaker 1990; Hunsaker 1993). Aside from the fact that cumulative impacts are very hard to assess within usual time, dollar, and data constraints, an EIS usually does not have a long-term plan or vision to guide or give context to the single proposed project. To address cumulative impacts effectively, we need to improve our assessment capabilities and to revise our management approach to environmental resources. To forge a better science-policy interface, we need innovative thinking and activities. A collaborative goal is required for this to happen, and knowledge of societal values is important. The World Bank identified four broad categories of unresolved questions for sustainable development: valuation, decision making in the presence of thresholds and uncertainty, policy and institutional design, and social sustainability (Serageldin and Steer 1994). The ecological risk assessment framework (Risk Assessment Forum 1992) and the cumulative impact framework (Irwin and Rodes 1992) strive to provide such a construct.

Buckley (1994) points out that cumulative impacts need to be included at three distinct stages of the environmental impact assessment process: (1) triggering the requirement for Environmental Impact Assessment (EIA), (2) during the analysis phase; and (3) during decision making based on EIA documents. With regard to triggering an EIA, one approach is to compare the total predicted impacts of a particular development proposal, including all cumulative components, with the best estimate of baseline conditions before any development. The alternative is to compare the predicted state of the environment, once modified by the likely impacts of the development proposal, with some predefined benchmark or ambient standard. In the decision-making process, the critical issue is the relative weighting given to marginal impacts from the proposed development, compared to impacts from other prior or concurrent developments. One approach is to establish tradeable development or environmental property rights with a fixed cumulative total.

Reasonable blueprints exist for addressing cumulative impacts in a more effective manner—the assessment and management frameworks discussed in this paper. However, cumulative impact assessment needs to be viewed as an ongoing process and not a one-time report. Numerous examples or case studies of cumulative impact assessments can be studied for insights. Tools and materials exist for assessments, but they are not complete. Cumulative impact assessments will continue to be difficult until we have the following (Hunsaker 1995):

- Monitoring designed for regional assessment
- More experience with ecological indicators
- Cause-effect relationships and more information from model comparisons at the ecosystem scale
- Tools for describing and modeling spatial heterogeneity
- Theory and data concerning the effect of spatial heterogeneity on ecological processes
- Better understanding of the error associated with data aggregation, remotely sensed data, and geographic information system processing.

To address cumulative impacts effectively requires a sustained effort that includes both evaluation of historic information and future prediction and planning. Neither science nor policy areas have an especially successful record of such sustained efforts (e.g., long-term ecological monitoring and data archiving, as well as comprehensive planning and implementation at all levels of government rather than crisis management). It is time to stop talking about cumulative impact assessment and management and start practicing it with the knowledge and tools that we have. Cumulative impacts are a key to understanding sustainability. Sustainable development can serve as the common goal that brings science and policy together.

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12

Environmental Assessment (EA) of Policies

John Bailey[1] and Stephen Renton[2]

Abstract

The need for an environmentally sound policy context in which to achieve sustainability is of crucial importance to current and future government decision making. As a component of the push to achieve sustainability, environmental assessment (EA) of government policy decisions is receiving renewed interest among both government officials and professionals. This paper introduces the concepts behind recent methodological developments in policy assessment, as well as discusses a number of examples of current policy EA practice before outlining several recommendations for future methodological developments in the area.

Key Words: policymaking, policy assessment, environmental assessment, strategic environmental assessment, decision making.

Environmental Assessment (EA) of Policies

The environmental assessment of policy decisions is one of the foremost requirements in government decision-making processes geared towards sustainable action, that is, integrating environmentally and socially equitable considerations into strategic (policy) levels of decision making (Sadler and Verheem 1996; Therivel et al. 1994). Although generally grouped alongside plan and program assessment under the banner of strategic environmental assessment (SEA), this review considers environmental assessment of policy decisions as a separate process—a separation that the nature of policy decisions in government warrants. Accordingly, this review discusses the development of policy EA theory and methodology, from its conceptual beginnings through the U.S. National Environmental Policy Act (NEPA) in 1969 to its evolution as a process based upon traditional environmental impact assessment, to current thinking on the most appropriate methods of ensuring policy EA's objective, sustainable government. Due to the nature of policy EA development, this review focuses upon policy EA methodologies in the context of policy EA processes as a whole, rather than specific methodologies that may be used within a prescribed process (such as checklists, matrices, etc.).

Approaches To Assessment

The concept of and provisions for policy EA based upon environmental impact assessment are not as recent as the current literature may suggest. The proclamation of NEPA in 1970 signalled the origins of EIA (environmental impact assessment) as we know it today, with early discussions on EIA (and NEPA) suggesting that its application extend beyond the discrete project level to include more strategic levels of decision making, namely policies, plans, and programs (Therivel et al. 1994). Despite the

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requirements of Section 102(2)(C) of NEPA for all agencies of the Federal Government to "include in every recommendation or report on proposals for legislation and other major Federal actions ..., a detailed statement by the responsible official ..." on the environmental impacts of such proposals, the focus of the majority of EIA practice, and relevant literature worldwide since the inception of NEPA has been primarily upon EIA as applied to individual development projects. Hence, although the concept of EIA at a strategic level has existed for some time, it is only recently in response to a greater awareness of the limitations of EIA confined to the relatively late stage of individual project authorization that renewed interest in policy EA (and SEA in general) has arisen (Lee and Walsh 1992).

To a large extent, the form that policy EA takes is determined by the objectives ascribed to the process. For example, the objective to integrate environmental considerations into higher, strategic levels of decision making (analogous to such integration at the project level brought about to a certain degree by project EIA) drives much of the current development in policy EA. Consequently, the application of EIA principles and experience to the policy domain is one of the predominant approaches to achieving this integration of environmental issues in decision making.

The increasing recognition of the need for sustainable development patterns has led some to posit an alternative approach to that of extending project level impact assessment principles and methods to policy EA. The concept of "trickling down" sustainability principles from policies to plans, programs, and, eventually, projects is seen as a means of addressing some of the perceived limitations of extending project EIA upwards—in particular, the failure to explicitly account for the intricacies of policy decisions as compared to project level decisions (for example, the variety of types of decisions in terms of subject matter, formality, levels of government and agencies both involved and concerned, and the types of procedures involved at the policy level) (Therivel et al. 1994).

Policy EA based upon traditional EIA as institutionalized through SEA is not, however, the only method proposed to meet the challenge of informed, sustainable, and equitable government policymaking. The use of policy EA in its current forms (see below) is seen by some as incapable of meeting the need for a policy assessment process that comprehensively and simultaneously assesses policy outcomes; that comprehensively assesses implicit as well as explicit, existing as well as proposed, policies; and that is both integrated with policy design and scrutinizes designs (Boothroyd 1995). Boothroyd proposes that these three processes be collected under the term *Policy Assessment* (PA), such that "PA is defined as the process by which fundamental policy options are continuously identified and assessed in terms of all highest level societal goals" (Boothroyd 1995: 105). In this sense PA becomes a process that fuses, and ultimately extends far beyond, the two general categories of policy assessment traditions—policy analysis and evaluation and policy impact assessment.

Policy EA from Environmental Impact Assessment

Much of the existing practice and literature dealing with policy EA as it has evolved from environmental impact assessment does so under the banner of SEA, often with little discernment between policy, plan, or program decision making and assessment. As a result, it is somewhat difficult to pinpoint developments in the area of policy EA specifically, as opposed to more general SEA trends. The lack of explicit policy EA processes and the growing number of SEA (i.e., policy, plan, and program assessment) processes (see following) further exemplify this point. Given these issues, this section attempts to extract policy specific information from the available literature.

One of the reports prepared under the recent International Study of the Effectiveness of Environmental Assessment presents the best opportunity to review information regarding recent trends in SEA (Sadler and Verheem 1996). Sadler and Verheem suggest that only a handful of countries and international organizations currently administer established SEA processes (that is, with process and practice formally organized), while many other countries use informal arrangements of SEA elements. Although the majority of strategic assessments to date have in fact been at the planning and program level (Sadler and Verheem 1996), it is under the guise of these SEA systems that a small number of policy EAs have been carried out. Countries and organizations that have experience in conducting policy EAs (either formally or informally) include Australia, Canada, Denmark, Hong Kong, the Netherlands, New Zealand, as well as the European Commission (de Vries 1994; Elling 1994; Gow 1994; Law 1994; LeBlanc and Fischer 1994; Norris 1994; Sadler and Verheem 1996).

From the perspective of process development, SEA is still at an early stage, with many issues (institutional, procedural, and methodological) remaining unresolved (Sadler and Verheem 1996). Not surprisingly, the conceptual framework for policy EA emerges largely from the development of SEA in general. Sadler and Verheem were able to discern three broad approaches to developing SEA:

- *Standard (EIA-based) model* — SEA of policies and programs generally patterned on project EIA (e.g., Canada)
- *Equivalent (environmental appraisal) model* — policy and plan evaluation undertaken to identify and take account of environmental effects (e.g., U.K.)
- *Integrated ("environmental management") model* — SEA undertaken as part of a comprehensive policy-planning framework (e.g., New Zealand).

These approaches typify the divergent concepts mentioned above in institutionalizing policy EA—the extension of project level impact assessment experience and principles upward, and the ostensibly more integrated approach of trickling down the principles of sustainability. Methodological developments in the area of policy EA alone are difficult to characterize due to the nature of SEA systems presently in operation. Many of these systems are not policy specific (i.e., plans or programs are generally included), and current SEA practice is in fact considered to be ahead of much of the preceptive literature (Sadler and Verheem 1996). Additionally, case examples of policies subject to some form of environmental assessment are few in number, a factor that may to some extent hinder the use of practical experience for further methodological developments. We must be careful not to misconstrue general developments in the area of SEA with more specific policy EA issues.

To further define policy specific developments, the following discussion of policy EA methods is restricted to those jurisdictions that have to date conducted policy level EA (these include Canada, Denmark, Hong Kong, and the Netherlands).

General consensus is yet to be determined as to what is an appropriate or suitable method for developing or carrying out a policy EA. Based on the information available for those jurisdictions that have attempted to assess policy level decisions, it is possible to present the following comparative data based on three key components of policy EA methods—provisions (i.e., legislative, administrative), scope (i.e., policy specific, or policies, plans, and programs), and prescribed procedures (i.e., formal procedures used, agency discretion).

Provisions

A mix of provisions exist worldwide for EA at the policy level, the dominant forms being formal legislative provisions and administrative orders. Examples of legislative provisions include the New Zealand *Resources Management Act* 1991 which contains as a specific requirement policy environmental assessment (Gow 1994); and the *EIA Act* 1987 of the Netherlands which requires certain activities such as sectoral policies and national and regional plans and programs to be assessed under the guise of SEA (van Eck 1993). The Netherlands is further distinguished by a two-tiered system where, in addition to legislative requirements for SEA, since 1995 a cabinet directive requires an environmental section (as part of an environmental test) for all cabinet decisions with significant environmental impacts (Sadler and Verheem 1996). Informal (i.e., non-legislative) orders also exist, for example the 1990 Canadian Cabinet Directive that requires an EA for all federal policy and program initiatives submitted for Cabinet consideration (LeBlanc and Fischer 1994); and the 1993 Danish Prime Ministerial Administrative Order requiring all appropriate Ministers to carry out policy EA as a part of proposed bills and government proposals (Elling 1994).

Scope

As indicated previously, few policy EA methods are designed solely with policy decisions in mind, rather they operate as part of an entire SEA process alongside plan and program assessment. Such is the case in Canada, Denmark, the Netherlands, and New Zealand. A slightly different system is in operation in Hong Kong presently, where an Environmental Implications Section (EIS) is required for, *inter alia*, new policy or strategy proposals, and environmental strategies, policies, and proposals (Law 1994).

Prescribed procedures

The policy EA methods operating currently can also be distinguished by the extent to which procedures for carrying out a policy EA are provided. The variations evident in this discussion are again symptomatic of the developmental stage in which policy EA is situated. In the Netherlands, policy EAs carried out under the EIA Act are required to apply identical procedures to project level EIA carried out under the Act. Such procedures include full public involvement, independent review by the Dutch EIA Commission at both the scoping (content of the EIS) and reviewing stages, examination of alternatives, and evaluation and monitoring of the implementation of the proposal (Sadler and Verheem 1996). In other jurisdictions, such as Denmark, the Administrative Order itself contains very few procedural elements. However, the Ministry of the Environment has issued a guidance document (see Denmark Ministry of the Environment 1994) that provides a checklist for screening and scoping of bills to determine if they have significant environmental impacts, further guidance for determining whether or not the environmental impacts are significant, and information on what may be included in an assessment. Alternatively, in Canada, agencies (ministers in particular) are allowed discretion and flexibility to develop and use procedures suited to their own agency's needs and circumstances (Leblanc and Fisher 1994), a feature that allows a policy EA method to develop in line with an agency's particular constraints and characteristics.

Policy Assessment

The approach to policy assessment proposed by Boothroyd (1995) in this review is an attempt to extend beyond the existing practice and theory entrenched in SEA. As we believe, comprehensive and successful policy assessment will require practitioners to move away from approaches evolving from the extension of EIA-based methods upward (i.e., the bottom-up approach). As an amalgamation of impact assessment and policy analysis traditions, ideal policy assessment as described by Boothroyd would break away from the tendency to simply extend policy assessment from either impact assessment or policy analysis and thereby focus upon both the attainment of the policy goals and the mitigation of undesirable side effects. Policy assessment could start afresh by synergizing

SEA's concept of formality (though not its specific procedures) with policy analysis' heuristic potential.

The following elements would characterize ideal policy assessment:

- Rather than linear EIA-like stages starting with screening by the initiating agency, ... [policy assessment] would be a continuous part of ongoing policy development.
- [U]nlike SEA which assumes hierarchical deductive decision making through logical decision-trees from policy to project, ... [policy assessment] would recognize the fluidity of decision making and the complexity of relations among decisions by encouraging assessment at any time, at any policy level from the general to the specific, at any point in the stream of causes and effects from policy to activities, in any policy sphere, by any party (Boothroyd 1995: 116).

Boothroyd argues that broadening policy EA based upon EIA to comprehensive policy assessment is a necessary progression (already underway) to achieve sustainability with high quality of life.

The true (as opposed to the ideal) nature of policymaking may ultimately require a method of policy assessment completely removed from impact assessment, such that we need to understand fully the peculiarities of policymaking as compared to those better understood project and planning decisions. As Boothroyd intimates, this may entail starting afresh; developing a new policy assessment process exempt from impact assessment bias and, more important, one that gives explicit notice to the realities of policymaking structures and processes as they operate within government and institutional circles.

Recommendations

Policy EA in every form is still evolving today, and much in the same manner as EIA twenty-five years ago, researchers and practitioners alike are just now attempting to develop appropriate concepts and methods and means of applying them to the policy arena. At present, policy EA practiced under the guise of SEA is by far the most favored institutionalized approach to address sustainability through assessment of government policies. However, as detailed in this review, what may ultimately be required is an alternative approach to current policy EA methods in order to adequately represent the realities of government and institutional policymaking. Recent studies (see Bailey et al. 1996) have in fact shown the need for an alternative mechanism to policy EA based upon impact assessment. Moreover, there is a need to specifically account for the realities of policymaking rather than relying upon an ideal or theorized view of a generic policy process. These two issues are without doubt major research priorities for the future development of policy assessment, in particular the need to develop further understanding of policymaking structures and processes, and the need to analyze the appropriateness of impact assessment based methods to these policy realities. Additionally, a number of issues to be considered in the development of specific policy assessment methodologies can be identified:

- The need to account for the varying policy roles of government agencies
- The need to account for the nature of policymaking as contrasted to project decision making
- The need to acknowledge an agency-dependent component within policymaking

- The need to explore all facets of policymaking, including policy implementation
- The need to explore greater links between higher level decision making and environmental databases (e.g., state of the environment reporting) (adapted from Bailey et al. 1996).

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13

Technology Assessment: Wanted — Dead or Alive!

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Abstract

Technology assessment (TA) embodies a concern that strikes a responsive chord throughout the world today: bridging the gap between societal needs and technological potential in acceptable and sustainable ways. However, the problems in dealing with the society-technology construct have fragmented TA as theoreticians, practitioners, and policy-makers seek to meet their own needs. Yet, important roles remain in both developing and developed countries for TA as a unifying concept, a learning process, and an information path for strategic alliances of technology researchers, producers, and development policy-makers.

Key Words: technology assessment, technology impact assessment, technology, impacts, technology management

Perspective: Is Technology Assessment Dead?

Technology assessment is dead! Long live technology assessment! If you search the literature today, you will seldom find titles including the words *technology assessment* (TA) without modifiers attached. *Needs-based, supply-driven, demand-driven, medical* (see Goodman, this volume), *information system, awareness, implementation*, and *constructive* are some of the modifiers. Further probing shows that most "TA" literature falls far afield from the early 1970s notion of a class of policy studies which systematically examine the effects on society that may occur when a technology is introduced, extended or modified. It emphasizes those consequences that are unintended, indirect, or delayed (Coates 1976).

Today's TA ranges from narrowly construed evaluations of specific, current technology options to general policy analyses with a technological bent (as undertaken by various offices of technology assessment) (Porter 1995). In short, there is a crowd of similar and dissimilar activities jostling for space under the TA umbrella. Why?

The question is worth considering because the answer may help us understand the interrelationships between the various "modified" TAs and the role that TA as future-oriented, broadly construed impact assessment (IA) still has to play. In its fullest form as "technology impact assessment," TA seeks to address a need that nearly everyone recognizes: to bridge the gap between what societies need and what technology can deliver in acceptable and sustainable ways. Even if what we do is really systems design,

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marketing, strategic planning, technology forecasting, or technology selection, adding "TA" to our activity alerts us to consider a broader array of impacts, needs, actors, and concerns than we otherwise might be inclined to.

The TA concept, although appealing, poses big problems. Technology and society are "all of a piece," so that only holistic approaches to assessment will ultimately serve. Yet our training, understanding, and methodologies are segmented. Moreover, the principal actors with stakes in TA are numerous, and the frames of meaning which guide their actions are diverse and seldom understood by themselves or others. Most actors don't even consider their role as actors in the drama of technological change and assessment. While some complain that TA is not well defined, the problem may be that it is only too well defined. Perhaps it is just too big and complex for us to deal with adequately. As the comedian Oliver Hardy would say, "This is a fine mess you've gotten us into."

The fragmentation apparent in proliferating TAs (choose a modifier) and impact assessments of different flavors recasts general TA concerns to fit our limitations and needs. Older TA methods are technology or supply driven, in the sense that they seek to highlight the impacts implied by technological change. Newer, demand-driven methods seek to shape policy to identify, encourage, or implement technologies that fulfill user needs. Still newer methods try to extend the search beyond technology users to the entire community. All TA is intended to influence policy and decision-making processes.

The ongoing evolution of TA can also be viewed in terms of changes in scope. In the 1960s, those with philosophical perspectives initiated TA with grand concerns about the interplay between technological change and society. Today, the onset of the information age, genetic engineering, and the initial emergence of nanotechnology cry out for such grand scale TA. However, the specific, broad-scope TAs of the 1970s (e.g., on electric cars or on hydrogen-based fuel systems) are "dead." They have been displaced by fragmented, narrower scope TAs. By contrast, environmental impact assessment (EIA), which originally focused almost solely on discrete projects, is now expanding in scope. Strategic Environmental Assessment (SEA), along with regional impact assessment, policy IA, cumulative effects assessment, and life cycle assessment all underscore broader scope impact assessments. These macro scope IA forms are fast emerging (see IAIA 1996; Sadler 1996; the "strategic assessments" articles of this volume). We should translate broad scope TA methods and experiences into these emerging IA venues.

Technology Assessment Practice

Despite the scarcity of new TA literature, we focus on several developments that are valuable to both the practitioner and the decision maker striving to manage technology. These are useful both for practical applications (e.g., to improve specific decisions) and as learning tools to help the various actors understand the implications of technological changes.

A primer and workbook commissioned by the United Nations Environment Program (UNEP) and prepared by Joseph Coates (1995) deals with environmental TA.[3] Coates provides a most effective exposition of the "old" technology-driven assessment process both for practitioners and for senior decision makers who must be aware of the potential environmental impacts of introducing a technology. It is focused on decision makers in developing countries, but is valuable in any locale. The primer is organized around three questions: (1) Why is environmental TA important? (2) What are its important elements?

[3] Strohmann addresses environmental TA as such, as do den Hond and Groenewegen 1996.

(3) How does one do it? The primer considers the technology cycle, sustainability, and the TA process (as nine interrelated, iterative steps that begin with examining the reasons for the proposed technology, continue through policy analysis, and conclude with recommendations). The exhibits that deal with risk analysis questions and environmental risk priorities are especially useful. Others deal well with potential results of public participation and the effects of a technology on institutions. The Phased Technology/ Demand Matrix provides a useful framework to assess the effects of a technology at the various stages of its life cycle.

The workbook is designed to be used either by an individual or small group with limited time and resources to increase their understanding and sensitivity, or by a task force with a more open time frame which seeks more definitive results. It is divided into sections on infrastructure and on manufacturing and production technologies. The workbook uses numerous exercise sheets to carry the reader through the nine-step process introduced in the primer. The approach feels relatively hard-edged and prescriptive, which is appropriate for the intended audience. While completing the exercises won't necessarily produce a complete TA, it will increase the sophistication of decision makers and practitioners alike.

Gerard Fourez (1994) provides a practical guide for technology-driven TA complete with suggestions for avoiding the pitfalls of interdisciplinary work and a list of reasons why various actors should participate in TA (i.e., make the technology more acceptable to society; clarify the decision process; define and meet conflicting interests; avoid undesirable effects; grasp opportunities; detect vulnerabilities of social organizations involved; modify the technology during its construction). The approach suggested is softer and more subjective than the primer and workbook described above. Nonetheless, it provides positive direction and a productive approach for anyone involved in a practical TA project.

Perhaps Fourez' most important advice is to replace the usual concept of a technology by that of a "new or evolving socio-technical construct" (NESTC). This construct emphasizes the inseparability of technology and society. Fourez' seven-step process begins by developing a relatively spontaneous, uncritical picture of the situation to make the team's starting point explicit. This picture includes initial glimpses of the affected technologies, social supply and demand, and the groups who will be involved.

In the second step, the team sketches a broader representation (called the Spontaneous Overall View) by considering the technology more closely; mapping the actors; developing the historical background; searching for norms and standardization; listing the issues at stake, and the tensions and controversies they imply; developing a list of social needs and demands, opportunities, supplies, and social vulnerabilities; identifying technological "black boxes" whose contents (at least initially) can be ignored; representing the technological framework; and listing the bifurcations where different actors may make different choices in the development path. These bifurcations later play an important role in the process when the team develops alternate scenarios for the NESTC.

In the third step, the team validates and expands its perception of the NESTC by consulting with "specialists" and with disinterested "pedestrians" who may provide special insights. The team opens some of the black boxes it identified earlier, but which it now perceives to be crucial, as its fourth step. In step five the team constructs a new theoretical model of the NESTC—one which is interdisciplinary and can provide a basis for public debate. In step six, the team constructs scenarios of possible futures implied by the significant bifurcations it identified earlier. In the seventh and last step, the team uses the TA as a framework for action by passing the information to those who can use it. Fourez suggests employing a consensus conference of "civilians," experts, and decision makers as a democratic vehicle. The process is sound but may provide fewer opportunities for involving the public than supporters of participatory TA wish.

The practitioner will wish to consult the other sections of this volume for methods related to evaluating impacts in various domains. Note the “Processes,” “Risk Assessment,” and “Domain-Oriented” sections.

TA’s Importance to Policy-Making and Management

The need for TA and TA-like activities has never been greater. There is a growing recognition that successful technology initiatives (with “success” defined any way you choose) increasingly depend on the societal aspects of the NESTC. Further, globalization of economies, a shift to demand considerations, growing populations, increased concern about the impact of technological choices on indigenous cultures and values, and growing concern for sustainable development all suggest a fertile climate for TA. However, practitioners must develop ways in which to make TA more effective in the policy-making arena.

All TAs, regardless of the variety or topical modifier, are intended to influence policy formulation and decision making. The influence of TA on policymaking has been disappointing. Even the respected U.S. Office of Technology Assessment’s demise was largely blamed on the poor temporal fit between its well-done analyses and the legislative cycle. Part of the problem can be traced to the fragmentation of the TA community and the sub-critical nature of most TA organizations. Smits, Leyten, and den Hertog (1995) identify four TA communities in Europe (industrial, parliamentary, academic, and executive). They note that these often are ineffective because they lack political legitimation and latitude, insight into how policy decisions are made, adequate funding, and experience; and, because they have been largely self-absorbed, communication between communities has been poor.

Can practitioners bolster the effectiveness of TA? They can to a degree through better communications based on understanding of the roles TA can play for the various actors. They also can build their capacity to function in a participatory environment. For instance, they can foster the use of TA to help negotiate strategic alliances among those involved in technical research, production, and development policymaking (Goulet 1994). While the context for Goulet’s suggestion is developing countries, it is sound for developed countries as well.

To accomplish this, practitioners must better understand decision-making processes and help the various actors more fully understand their roles, rationales, and options. These strongly depend on the internal frames of meaning which guide the actors’ choices. Although frames of meaning are seldom explicit and are usually unexamined, Grin and van de Graaf (1996) suggest that “if the frames of meaning of the technology assessor do not match those of the policy-makers, it is not likely that TA will significantly change the policy plan or that the technology assessor’s perspective will be considered politically legitimate by the policy-makers.” They use the example of recent wind turbine development in Denmark to show that policy-makers, technologists, and technology managers view a technology in very different ways that shape their choice of a preferred technology. Undoubtedly, they shape the actors’ views of TA as well. Grin and van de Graaf propose that TA can be an important learning experience to force the parties involved in policy formulation to examine their frames of meaning, and they hypothesize that the actors need only share congruent rather than identical meanings.

In the same vein, Goulet (1994) discusses the interaction of technological, political, and ethical rationality in the decision-making arena. He formulates a model for interaction that is “circular and reciprocal, not vertical and reductionist.” This could prove useful to assessors in synthesizing disparate perspectives.

Goulet (1994) concludes by asserting that, for developing countries, “Technology assessment, which is both a general approach and a precise technology, ought to be conducted as a broad participatory process that bears primarily, though not exclusively, on the qualitative features of development.” This observation is in concert with demand-driven TA, whether in developed or developing countries. Goulet also identifies three institutional roles in developing countries: technological gatekeeping, providing a focus to receive and communicate technological information for TAs, and assuring information exchange among relevant actors. He also proposes a key for evaluating the significance of various indicators as well as relevant questions that need to be asked. Finally, Goulet posits a model in the form of a flower with six petals (social, political, full-life meaning, cultural, ecological, and economic) that can be used to synthesize scores assigned to each by the various concerned communities. While Goulet’s work is focused on developing countries, there is much here that can be applied to other situations.

Recommendations

The intent of TA is sound and widely embraced, though variously interpreted. Announcements of its death need to be recast into calls for its evolution into diverse modalities. TA provides a framework within which to synthesize the knowledge generated by the various approaches that are presently practiced, and for the knowledge and techniques being developed in impact assessment. However, practitioners and theorists must attend to holistic ways to handle the technology-society coupling. Demand perspectives appear to be supplanting supply (technology-driven) rationales for TA. Considerable work still remains on techniques for accommodating and weighing systems of evaluation to incorporate both qualitative and quantitative indicators.

Ultimately, TA needs to become a strong element of the policy-making/decision-making milieu to survive. To be effective in influencing policy, practitioners should build strategic alliances with those involved in technological research, production, and policymaking. These alliances offer strong venues for TA as (1) a process to sensitize the various actors to the implications of societal demand and the impacts of technological decisions, and (2) paths for TA information flow and bases for negotiation. But if the promise offered by strategic alliances is to be realized, practitioners must expend considerable effort to better understand how policy decisions are actually made. They should also lend their support to the development of TA databases such as those being built in some European countries (see Strohmann) and information systems to tie them together, such as that outlined by Laopodis (1994).

Multiform TA and impact assessment add to the accumulation of knowledge which one day we may apply to address the broad scope concerns of technology assessment. We must preserve the TA concept as a unifying principle. We also suggest that TA methods and studies of TA’s flawed performance in the policy arena can contribute to the crafting of effective SEA. We invite readers to compare this discussion of TA with those of SEA, cumulative effects assessment, programmatic EA, and EA of policies in this volume—they share much in common.

A particularly profitable role for TA in the near term is as a learning process and a stage upon which actors can meet to better understand their actions, the actions of others, and the complexities of the NESTC.

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Methods for Environmental Impact Assessment: Selecting a Model and Approach

Ron Webster[1]

Abstract

Since the enactment of NEPA (National Environmental Policy Act), and following some twenty-five years of NEPA experience, there are some major issues which surround the value (efficiency and effectiveness) of the NEPA process. While some of these are procedural, others are related to the selection of scientific (modeling) tools. The Army has used a simple modeling tool to address regional economic impacts of its actions (such as Base Realignment and Closure[BRAC]), and, while the methodology can be improved, many of the model's characteristics have made its use in Army decision making (NEPA analysis) both efficient and effective. The increased use of less sophisticated, but scientifically defensible methodologies might go far toward the efficient and timely provision of information to decision-makers, thus better supporting the effectiveness of the NEPA process.

Key Words: economic modeling, environmental impact analysis, U.S. Army

Introduction

The passage of the National Environmental Policy Act (NEPA) (42 USC 4321-4347) marked the establishment of a cognizant and articulate national desire to protect the environmental resources of the nation through national environmental policy. This development was not a short-term manifestation, or an instantaneous product of the 60s liberalism, as is often perceived. NEPA represented the end result of a step-by-step, sequential and evolutionary process which perhaps began as early as 1864 with the publication of George Marsh's *Physical Geography as Modified by Human Action*. This publication first identified the trend toward irreversible and irretrievable foreclosure on nature's largesse. Subsequent thought led the national psyche from the "fear, loathing, and domination" of nature toward the notion of man's coexistence "in harmony" with nature. This overall process represented the increasing national realization that man had the ability to permanently alter the landscape and nature, and thus foreclose on the options for future generations, often without a full realization of impacts, and essentially acting in ignorance of environmental ramifications. With the subsequent industrialization of the nation and the development of unprecedented, man-made chemical processes and products, this realization became a critical issue, leading to the passage of numerous other environmental protection statutes in addition to NEPA. The U.S. public, through these statutes and subsequent regulations, continues to promote protection and enhancement of the environment and public health. NEPA is meant to be the mechanism through

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which decision-makers are made aware of the impact of their actions and the alternatives available which will lessen, or ameliorate, the negative impacts associated with contemplated action. As envisioned, this mechanism is an elegant experiment in the application of democratic principles, assuming that a reasonable decision-maker, aware of alternatives and trade-offs, will make the right decision. In short, NEPA simply attempts to ensure that decision makers make informed decisions.

While NEPA was an accurate portrayal of public concerns in 1969, implementation of the statute has often been criticized as inefficient and ineffective (Council on Environmental Quality (CEQ) 1997). The most common criticism of NEPA has been the perception—by the very decision makers NEPA should assist—that the NEPA process as a “post-decisional” process, accomplishing little more than the imposition of a bureaucratic process which often delays projects, wastes resources, and adds little to solving the needs of the project or processes being implemented. In most individual cases, this is a valid criticism. While much of this criticism is self-fulfilling, or dependent upon the way in which the decision-maker chooses to use NEPA, some of the criticisms stem from the response of the typical NEPA analyst to the challenge of informing the decision- maker. While the other two components of an informed decision—technical feasibility and economic justification—are available to the decision maker, the environmental impact analysis is seldom complete and seldom conclusive in its final presentation. In addition, the conclusions are often difficult for the decision-maker to assimilate and understand, for they encompass numerous and disparate disciplines, each of which often exacerbates the problem of synthesis and informed decision making. Common preoccupation with developing “bulletproof” documents leads to the inclusion of too much information for the decision maker (often making the actual document unreadable), the natural tendency to expand the “state of science,” and the resultant tardiness of environmental considerations in the process of decision making (Bausch).

The practical implementation of NEPA has spanned over twenty-five years, and much has been attempted in the development of methods and models to analyze and present the impacts associated with projects and programs. Throughout this period, agencies have completed a large number of EAs and EISs using a variety of tools, from the simple to the complex. Some of these methods have worked well in meeting the objective of informed decision making, and observations can be made regarding the general nature and specific attributes of successful methodologies (i.e., those that efficiently and effectively affect the decisions being made). An understanding of these methodological attributes may lead to the development, refinement, or use of more appropriate models, subsequently leading to more effective representation of the environmental issues at the decision-making table.

NEPA Requirements

A review of NEPA and subsequent CEQ regulations (40 CFR, 1500-1508) (CEQ 1992) implies that the accurate, indisputable prediction and presentation of environmental impacts is a recognized impossibility. There are adequate provisions to discuss and present issues of data unavailability, weaknesses in predictive methodologies, and other shortcomings of imperfect science.

In spite of NEPA’s acknowledgment of predictive uncertainty, the inclusion of sound science into decision making is clearly prescribed by statute and regulation, as well as the identification of scientific and technological needs in support of sound environmental decision making, as a matter of national policy. This should allow for the development of NEPA-specific science (tools) that address the compromise between the demands of exact, detailed science and the needs of a decision maker.

Many of the methods used in traditional EIA practice represent the more traditional role of academic pursuits, the advancement of knowledge, and encouragement of dialogue between scientists and engineers in pursuit of this knowledge. As much of the scientific analysis of environmental impacts is done by academic professionals, there is a natural tendency toward more sophisticated methodological approaches which may be more interesting from an academic standpoint, but frustrate the education and assistance of an environmental decision maker. It is likely that the more desirable model, from a NEPA standpoint ,would trade sophistication for other attributes that better address the needs of the decision maker, and thus, the practical needs of the NEPA analyst.

In addressing the requirements of NEPA, the U.S. Army has used a specific methodology which has served the agency well. This methodology has been widely recognized in Army decision making, and many of its attributes can provide insight into the attributes of those methods which can best support and effect better environmental decision making. While the tool will be discussed in some detail, this discussion will be for purposes of illustration, as opposed to promotion. However, experience associated with the use of this tool may serve to better focus the evaluation of methods which would best address or overcome many of the criticisms of the NEPA process.

The Economic Impact Forecast System (EIFS)

The Economic Impact Forecast System (EIFS) (Huppertz et al. 1994) was developed in the early 70s, at a time when the requirements for sound EIA were not well known and there was little experience to exploit. Focused on regional economic impact analysis, the development of EIFS followed an analysis of three different general approaches; export base (Teibout 1962), econometrics, and input-output (I-O) (Richardson 1972). The resultant product (tool) utilizes the export base approach to regional economic impact prediction. This selection was based upon (1) the general acceptability and dependability of the method, (2) ease in implementation, and (3) applicability to the needs of NEPA.

While the popular regional economic modeling technique of the time was I-O, the theoretical underpinnings of the export base technique appeared sound and it was a popular technique for use by analysts facing limited resources or time. While some research was required to “tune” this approach (Isserman 1977), the general theoretical acceptability was judged as sound.

The implementation of the export base technique was very simple relative to the implementation of an I-O model, which traditionally involves the regionalization of a national or state table using data derived from survey-based sources. In comparison, the identification of export employment could be easily approximated using the location quotient technique. The resultant economic multipliers, derived at the four-digit SIC level, compared favorably, at the aggregate level, with the results of survey-based I-O research (Bloomquist 1988). In addition, a nationwide database was readily available (through the Department of Commerce) for nationwide Army implementation and use. It was obvious that a composite tool (models and database) could be made available on the emerging computer technology of the time (Jain and Webster 1977). This tool or method was thus made available to DoD NEPA analysts (including contractors) as an interactive computer system (through phone lines and modems), and a typical scenario (alternative) could be processed through EIFS in fifteen to twenty minutes of elapsed time once a few input data elements (characterizing the action or alternative) were known.

The applicability of the export base technique to NEPA was a critical consideration. While alternate methods provided more detail to the analyses, this detail was not required to adequately inform a decision-maker regarding the relative impacts associated with various alternatives. An aggregate measure of impacts for each alternative could be readily supplied, and additional detail was rarely sought. The best support for the use of this technique was supplied by a world-reknowned regional economist addressing this issue who stated, "As long as you merely want to rank-order relative impacts, this approach would be acceptable" (Niehuff 1980). This "rank-order" oversimplification does apply to the essence of the NEPA mandate to compare and select among alternatives.

The widespread use of EIFS in DoD was stimulated by two major court actions (*McDowell v. Schlesinger* and *Breckenridge v. Schlesinger* 1975) and a court decision addressing the applicability of socioeconomic considerations to NEPA was established (*Hanley v. Mitchell* 1976). In short, the use of EIFS throughout the Army—and other elements of DoD—became extensive. This extensive use constantly led to issues associated with the need to better evaluate the "significance" of predicted impacts from the EIFS model. While some arbitrary "rules of thumb" were attempted by DoD, they failed in many applications due to a lack of regional specificity. To address this need, the Rational Threshold Value Technique (RTV) (Webster and Shannon 1978) was developed using the analysis of regionally-specific trends (as represented by Department of Commerce time-series data) to ascertain the significance of impacts. With this addition to the toolbox, the method now included the database, the model, and a means to measure significance. The popularity of this new composite tool became firmly established within the DoD user community. This popularity continues today and the tool is mandated for Army NEPA analysis associated with Base Realignment and Closure (BRAC) actions (U.S. Army 1995). The use of EIFS for BRAC projects has been the subject of two Government Accounting Office (GAO) studies, and its utility and applicability has been upheld.

Two additional evolutionary additions have been made to EIFS: the development of modified I-O technique (Bloomquist, Webster, and Robinson 1987) to better and more-extensively address those cases where the predicted impacts cross the significance threshold (leading to a two-tier EIA approach) and the development of a more rigorous statistical technique (U.S. Army Construction Engineering Research Laboratories (USACERL) EIFS Tutorial 1987) to supplement the RTV approach. While these are significant to the application of EIFS, the evaluation of EIFS as a NEPA-specific analytical method gains little from their presentation and discussion. As a result, they are not discussed.

The EIFS system has been extensively used throughout the Army to address the regional economic impacts as part of NEPA analysis. It is responsive to the analyst and requires little in terms of input data or resources to exercise the system in the evaluation of alternative scenarios. Economies of scale are obtained through the centralized maintenance of the national database for the benefit of a much larger user community, insuring that the data are readily available. The system has proven to be very responsive to the decision-making process, allowing the analysis of numerous scenarios (alternatives) and providing ready documentation of the process. Critics of a resultant EIA have been provided access to the system and allowed to perform their own analyses, and such an open exchange has yet to reverse the results of the analyses. This is directly attributable to the inherent characteristics of the EIFS methodology.

Based upon approximately twenty years of experience with the EIFS methodology, the following attributes constitute a good NEPA tool:

- *Ease of use and efficiency*: The system should be easy to use. A user should be able to analyze numerous scenarios easily and the user should not be overly burdened with input requirements. The system should be capable of efficiently analyzing a large number of alternative impact scenarios.
- *Flexibility*: The system should be sufficiently flexible to analyze a variety of standard impact scenarios as well as handle emerging, non-traditional issues.
- *Consistency and comparability*: The system should be methodologically, procedurally, and empirically consistent when applied in a variety of locations and circumstances over a period of time.
- *Reproducibility*: The results from the system should be reproducible, independent of any specific analyst.
- *Explainability*: The methodology, procedures, and results of the system should be explainable to a wide variety of audiences, both to experts and the general public.
- *Defensibility*: The methodology, procedures, and results of the system should be defensible. The system should be able to withstand peer review by leading experts in the field.

Lessons Learned from the EIFS Experience /Applicability to NEPA Practice

Availability of Data

The major strength of the EIFS system is the availability of an acceptable database and the integration of that tool with an appropriate predictive technique. This database is national in scope and is readily aggregated to produce any multi-county region of influence (ROI) for the assessment of impacts. The database does suffer from some issues of timeliness, but this is only an issue if the region has undergone unprecedented or major changes, and those cases are readily identified. This windfall in data from the Bureau of Commerce cannot be attained as easily in other technical areas of EIA. Ironically, baseline data are seldom readily available to the NEPA analyst, yet numerous agencies and institutions are constantly acquiring and storing data. Information (the synthesis of data) is constantly created, but it is often difficult to obtain and its integrity must be verified. Access to numerous federal (nationwide) databases is becoming easier in a practical sense, as a result of better communications and the advent of information technologies (IT) such as CD-ROM, electronic mail, the World Wide Web (WWW), and other technological developments. These data sources include the traditional federal agencies (U.S. Geological Survey, Environmental Protection Agency, National Oceanic and Atmospheric Agency, National Resources Conservation Service, etc.), while other private efforts at the creation of national databases appear very promising. Similar state agency efforts are also becoming increasingly common. The content of all these data collection efforts could be identified, characterized, standardized, and made efficiently available to the NEPA community at large. The unprecedented acceptance of the WWW (Krol 1992) and the recent establishment of NEPAnet on the WWW (CEQ Web site) are promising in this regard, if an interface to predictive tools can be established and the issues ofstandardization and data integrity (White House 1994) can be addressed.

Simplicity of the Model

Often, simplicity is considered a weakness in a methodology, and, even more frequently, the output from a sophisticated model is considered more valuable. In the context of a NEPA application, these can be unfortunate judgments, as the complex model often requires more extensive input data and the inner workings of the model are more difficult to explain to the public. A simple model (with a sound theoretical underpinning) can be advantageous from the standpoint of its efficient assessment of impacts which minimize the costs of data acquisition, preparation, and use, and, in addition, expedite the provision of information to a decision-maker. While a sophisticated model can often provide better or more detailed results, a simpler and more responsive model may provide sufficient data to support the decisions being made. Unless the more detailed analysis leads to different results, the investment and delay associated with sophistication may be unnecessary; and these delays can keep EIA out of the decision-making process.

Significance

Little frustrates the decision-maker and disappoints the analyst more than the inability to address what model output actually implies. Nothing is so painful as the "So what?" response to a presentation of model results. Significance must be based on context and intensity and, among technical disciplines, different criteria can apply (historical perspective, violation of standards, etc.). Every presentation of model results should include a measure of relative significance among alternatives under consideration, and these measures must be regionally specific, addressing the specific situations that are being evaluated. In the twenty-five years of NEPA experience, some evolved, standard interpretive aids (for the determination of significance) should exist, and these should be identified and made available to the NEPA practitioner community.

The Effects of Emerging Future NEPA Issues

Traditional Issues

The use of predictive models in traditional EIA has almost always required some compromise between the application of the ideal model and meeting the needs of the target decision-maker. There are often pragmatic time and resource constraints which place limits on the level or the detail of data acquisition efforts that can be expended in support of a given model. In some cases, data may not exist to run a model which would be ideal, or "perfect," for the analysis of a given impact. The demand for informed decision making places timeframes and budgetary constraints on the process, and these are simple realities which the NEPA practitioner is accustomed to facing. The practical model is, then, the model which is based on sound theoretical underpinnings, is commonly accepted in the scientific community, and is supported by a readily acceptable, dependable source of data to drive it.

Cumulative Impacts

There is currently widespread interest on the part of NEPA practitioners to better address the potential "cumulative" impacts of a project, consistent with NEPA requirements and subsequent CEQ considerations. This interest will dictate that applicable models accept data and address impacts associated with "past, present, and reasonably-foreseeable actions" in the given geographic ROI. If such a notion prevails, the problem of adequately describing and modeling the traditional proposed actions and alternatives will pale in comparison to the new task, which will involve the acquisition of model inputs for all the other activities which cumulatively impact the environment. This will require the acquisition of data on those other projects, magnifying the necessary investment in data to drive the models of choice and exacerbating the issue of compromise in the selection of an appropriate or practical model.

Regional Ecosystem Management Concepts

The concept of total or regional ecosystem management is becoming commonly accepted as a fundamental tenet of sound environmental management and protection. This follows the acceptance of biodiversity as a goal, the increased geographic requirements that are required to achieve that goal (Wilson 1988), and the use of adaptive environmental management (Carpenter 1995) to offset uncertainties in biological/environmental prediction and management. The resultant expansion in geographic coverage or scope will make detailed prediction and analysis more difficult and expensive to accomplish, giving rise to the increased utilization of such tools as GISs and satellite and aircraft imagery. More general approaches and methods must be specified, addressing the constituent components of the overall region under analysis. Sustainability of both environmental resources and economic growth are forcing the development of composite approaches (Washington Forest Practices Board 1994) to ensure the use of appropriate, efficient, and effective tools capable of informing the environmental decision-maker.

Summary

The criticisms of EIA are often due to the inability of the practitioner to provide appropriate information to the decision-maker in a clear and concise way. In addition, the process can be costly and time-consuming. Often this situation can arise as a result of incorrect model selection, losing site of NEPA's original intent to inform the decision-maker. Many of the criticisms stem from the lack of integrated tools or methodologies which more specifically address important aspects of the NEPA analysis process (data, models, significance measures). As EIFS represents a unique and fortuitous situation which may be difficult (or impossible) in other technical disciplines, some attributes of the EIFS methodology are worthy of note, and can improve the responsiveness and viability of EIA methods with regard to addressing the overall objectives of NEPA.

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The Environmental Overview as a Realistic Approach to Strategic Environmental Assessment in Developing Countries

A. L. Brown[1]

Abstract

Strategic Environmental Assessment (SEA) is currently a much talked about, but little practiced, tool. This creates difficulties for developing countries in that there are strong pressures for the rapid and often indiscriminate transfer of new "technologies" such as SEA from the developed to the developing world. A new member of the family of environmental assessment tools, the Environmental Overview (EO) has been developed by the United Nations Development Program (UNDP) for the assessment of aid projects. It has been extensively trialed in training programs in developing countries. The environmental overview represents a major advance as a form of strategic environmental assessment for programs, sectors, or policies in an international aid context; but will find widespread general use outside the UN system. The environmental overview is a participatory creative process used in the formulation stages of development activities which leads to early identification of environmental and social impacts, opportunities for those programs, and direct feedback into program redesign.

Key Words: development, aid, projects, programs, environmental impact assessment (EIA), strategic environmental assessment (SEA), plans, policies, sectors, UN, social impacts

Strategic Environmental Assessment and Development Assistance

The term Strategic Environmental Assessment (SEA) represents a convenient description of a formalized process of assessing, at the earliest possible stage, the environmental and social impacts of decisions made at policy, planning, and program levels. As well as applying to specific policy decisions, some form of SEA is appropriate to those actions which fall outside of the scope of project-based Environmental Impact Assessment (EIA): for example, small projects such as multiple housing or tourism developments which collectively, rather than individually, have environmental consequences, or non-project actions, such as changes in farming or forestry practices that cannot be satisfactorily regulated through the approval of capital schemes (Lee and Walsh 1992). The supposition in SEA is that policies, plans, and programs are amenable to environmental assessment, similar to the way that mining, industrial, or infrastructure projects have been subject to assessment through the traditional EIA process of the last few decades. While various countries are experimenting with different SEA approaches, experience is as yet too limited to conclude how effective such systems are (Partidario 1996) or to specify the most desirable approach toward strategic assessments (Verheem 1992).

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Today there is rapid transfer of technology from the developed to the developing world and to countries in transition. This includes the "technology" of environmental assessment methods, though Brown (1990) has commented that in some respects classical project-based EIA may have been an inappropriate technology transfer. With so much current emphasis in the literature on SEA, attempts to transfer it to the development context will be widespread. A new tool is always seductive both to practitioners and administrators in developing countries, and western experts are not shy to offer a new product, even if that product is still little more than a broad notion, unmandated and largely experimental, in most developed countries. There is a danger that the present chimera of SEA could be adopted rapidly and unquestioningly in developing countries in the same wholesale fashion that project EIA was—without trial and adaptation to local needs.

Development assistance is one area which is in immediate need of the type of assessment provided by SEA. Whereas, in the past, aid has been in the form of projects amenable to project-based EIAs, most aid today is "softer." It is not project based. It may be programmatic—a range of interrelated activities under a single theme. It may provide wide-ranging support to a sector or sub-sector of government. Moreover, it may focus primarily on in-country capacity building, both through human development and institution building, over the complete range of governmental and non-governmental activities. Projects such as *developing the capacity to privatize state-run enterprises,* or *technical assistance to develop a fishing industry,* or *promotion of export growth,* or *capacity development for land use planning,* are the norm.

These types of aid projects deal with activities which occur rather upstream in the decision-making cycle. They deal with whole programs, even whole government sectors. Often in their capacity-building focus they are part of policy development. Clearly, these trends require assessment tools which operate at a more strategic level than project-based EIA. Lee and Walsh (1992) noted that some of the multi-national and bi-national aid agencies and banks are showing interest in the extension of environmental assessment to the more strategic levels of planning and decision making (e.g., World Bank 1993; Goodland and Edmundson 1994), but actual practice to date is fairly limited. Scanlon (1994), Mahony (1995), and Kennett and Perl (1995) all note the need for upstreaming environmental assessment in development assistance programming activities.

The Environmental Overview

In the last four years, UNDP has gained valuable experience in the environmental assessment of aid projects of this type. This has been through their development of environmental management guidelines (UNDP 1992; Sen, Panayotou, and Reid 1992) and an associated extensive training program for field staff and national government counterparts. As at the end of January 1995, 107 training workshops had been completed in over 95 country offices, with 2783 participants, of whom 35% were UN staff, 50% were government counterparts, and 15% were non-governmental organization (NGO) staff.

The core of the technique is the environmental overview. Brown (currently under review) has recently described the environmental overview process in full, but a summary is provided below, together with an analysis of how it conforms to many of the requirements which contemporary authors suggest are necessary for an effective SEA methodology. This new tool warrants widespread exposure, as it has proved effective not just for the task for which it was designed—the environmental evaluation of aid projects—but also for in-country assessments of programs and policies completely unrelated to UNDP activities. In fact, it appears that the environmental overview may prove to be a highly effective model for SEA in developing countries.

The environmental overview is a process used in the formulation stages of programs. It leads to early identification of environmental and social impact—and opportunities for those programs—and the incorporation of steps to mitigate those impacts, or enhance those opportunities, directly into program redesign. The environmental overview tool was specifically designed to overcome the checklist mentality which tends to prevail with respect to much project development. It was based on the observed failure of thematic checklists to meet with little more than bureaucratic compliance and an insignificant impact on program formulation.

The environmental overview process is described in the original *Handbook and Guidelines for Sustainable Development* (UNDP 1992), but has evolved considerably since this book was published (United Nations Industrial Development Organization (UNIDO) 1994). Brown (1996) provides the only available summary of the most recent evolution of the environmental overview and describes the four critical aspects for its successful application:

- The project/program must be in its *draft* formulation stages.
- There must be sequential completion of each of the structured “questions” of the environmental overview.
- The environmental overview must be undertaken participatorily, using a broad mix of specialists and others.
- The process must include modification of the draft project/program as an integral part of the environmental overview. The tool should be recognized as a creative process, not just a document.

The tool is very flexible, and in practice has been applied to non-geographically based projects and programs, to sectoral activities, and to policies. The environmental overview can be completed with considerable speed, perhaps in a single day or less. This, together with its participatory involvement of proponents and other stakeholders, leads to its effectiveness in project selection, or abandonment, and modification.

The environmental overview asks a set of questions, similar to those asked by conventional EIA, but with different emphases. First, it asks questions concerning the baseline conditions for the project/program:

- What are the biophysical and social environments of the project area?
- What are the major environmental and social issues which currently exist in the project area?
- What are the economic forces which are currently operating in the project area?
- What are the current management practices and capabilities in the project area?

Next, it asks questions concerning the project/program impacts and opportunities, and how the draft project/program can be redrafted in an operational strategy to take these, and the baseline conditions, into account:

- What are the major natural and socio-economic impacts and opportunities associated with the implementation of the project?
- What modifications/alternatives are there for project design?
- What is the operational strategy to achieve the modifications/alternatives or to address issues described in the baseline conditions?

Additionally, the questions address what modification should be made to the original project/program design as a result of the overview. Answering these questions results in a brief document. However, it is the *interactive process* of assembling the environmental overview document, including any consequential changes to the project/program, rather than the document itself, that is at the heart of the process.

The essence of the environmental overview lies in the wealth of expertise that can rapidly be brought to bear on a proposed development by interactively involving a range of parties in a group, and by this group's constructive dynamics. In the training courses, the following mix of participants were used to very good effect in the practical application of the environmental overview to existing or proposed projects/programs. To generate a diversity of views, the mix included professional UNDP staff and their government counterparts responsible for project formulation, local representatives of other UN agencies, and representatives of major environmental NGOs. Government counterparts included representatives of many line agencies such as health, energy, women, forestry, agriculture, water, industry, tourism, fisheries, coastal management, planning, or finance. While this mix was chosen originally for training purposes, it has proved to be a model of how an environmental overview can be conducted in practice. A breadth of line agency representation in the environmental overview of all projects is critical, and a recognition that development interventions always result in complex changes to parts of the biophysical and social environment other than those specifically targeted by the activity itself. Prejudgments that an environmental overview of, say, a roading project need only involve the transport line agencies, would be myopic with respect to the wider systems changes that could occur—changes to environment, agriculture, markets, land use, etc.—as a result of changed accessibility, for example. In the best possible scenario, preparation of the environmental overview would be extended to include the participation of those directly affected by the development. Despite rhetoric to the contrary, in most development planning to date there has been little practical experience of real participation by affected parties, and the environmental overview process provides a practical mechanism by which participatory development techniques could be applied in the project formulation process. Where the development proposal involves a specific geographical location, field visits by participants could be a highly desirable, but often logistically difficult, component of the process.

Experience has been that the wide range of views provided by a mix of participants is essential to set the proposed project/program in the context of its environmental and social systems. For example, in conducting an environmental overview of a project intended to build in-country capacity in tourism, the contributions that health professionals made with respect to the community health issues associated with tourism demonstrated a major failing in the original project conception, and led to modification of the project. Furthermore, because these modifications would be suggested by the environmental overview at a very early stage of project/program development when budgets, terms of reference, and time lines were still quite flexible, proponents were able to be receptive to the proposed modifications, much more so than had they been suggested after the project design had been largely finalized (as is usual with conventional EIA).

The operational strategy of the environmental overview is one of *building into a modified project/program proposal* ways of investigating and addressing those environmental and social issues which would arise from the project itself, and those environmental issues which pre-existed the project. Because the environmental overview should be undertaken at the earliest formulation stages of the project/program, this can readily be achieved by inserting new budget items, time lines, or personnel requirements in the redrafted proposal. The nature of most development activity is such that, unless these matters are resolved *within* the redrafted project/program, or at least by the consequent generation of additional projects/programs to specifically address them, then they are unlikely to be resolved by any other action.

Experience has been that a group consisting of the broad mix of interests described above, together with appropriate resource documents, can provide answers to all questions in sufficient detail to ensure that the environmental and social system in which the project will take place is understood, and that the most significant issues are raised and resolved. Experience has also been that development practitioners with no environmental training can readily introduce modifications into a project/program once the environmental issues and opportunities have been brought to their attention and clear environmental objectives set.

The environmental overview is based on the premise that knowledge and skills *to recognize* (not necessarily *to solve*) the broad environmental and social issues associated with development proposals, and to maximize opportunities within development proposals, reside in-country and can be harnessed through the participatory group process described here. If *solutions* are not obvious to groups completing the environmental overview, then their strategy has to be to build into the *revision* of the project/proposal budgets, specific tasks, and specialized personnel to generate the solutions. For example, in the capacity building project for the tourism sector referred to above, the solutions to the associated health problems of tourism were to be addressed by modifying the terms of reference for the project's chief technical adviser to include health responsibilities, and for specialized personnel and budgets for health to be built into the multi-skilled team to be appointed to build tourism capacity in the national government.

The Environmental Overview As SEA

There are divergent views regarding whether EA at the strategic level should simply be an expansion of concepts, processes, and legislation as currently apply for project level EIA (see Wood 1995 for the various legislative requirements in the U.S., California, and the Netherlands) or whether SEA needs to take on quite different modes of triggering, functioning, and outcomes, borrowing only fundamental principles, not form, from project-based EIA. The experience with the environmental overview is that, in developing countries at least, the latter will be the way forward.

What are the bases for claiming that the environmental overview is a highly effective model of SEA? One is simply that it works. This author has participated in environmental overview applications, albeit in training, to more than twenty projects, programs, or policies in more than a dozen countries. Somewhat more speculative is the observation that the participatory discussion on the nature of the problems, and the possible solutions put up by the environmental overview, fit more comfortably with the way conflicts are resolved in the cultures of many developing countries than do the more analytical and aloof processes provided by EIA-type approaches. More convincing, perhaps, than these personal observations is noting that the environmental overview process conforms to many of the emerging principles for effective SEA espoused by contemporary writers:

- Environmental assessment should not cause delay in strategic decision making because of the time it might take to prepare a strategic EIA. In strategic decisions there is no single decision-making moment as there often is with project decisions. Policy is continually added to, modified, or even withdrawn. Therefore, a strategic EIA must be able to be drafted quickly to provide the right information at the right time in this continuous process. It must not need years of study to provide this information (Verheem 1992). The author notes that the Dutch Etest, asking the right questions during policy formulation, is one way of achieving this.

- SEA must not stand alone from decisionmaking, but should integrate EA principles directly into the decision making process (Sadler 1994).
- Partidario (1996) notes that SEA is intended to look at a range of possible alternatives in programs, policies, and plans in a way that is systematic and ensures full integration of relevant issues in the total environment, including biophysical, economic, social, and political considerations.
- The focus of the SEA must be on process, not on product (Partidario 1996). Rather than the production of an SEA report, effort must be on an iterative and continuous process that assists the on-going policy-making process.
- Because SEA operates at a different point in the planning process, and at a different level of generality than does EIA, then it is to be expected that there will be different procedural and methodological differences between them (Lee and Walsh 1992). There are few officially acknowledged methods for SEA (Therivel et al. 1992), and new forms and procedures relevant to particular settings need to be urgently developed and tested. Simple methodological approaches are required.
- There is a reasonable premise that prediction based on sophisticated modeling may not be required in strategic assessment to enhance decision making (Dixon and Montz 1995). Differences in scale increase the complexity of SEA relative to EIA, but the degree of detail and the level of accuracy of information needed for policy, plan, and program decision making is generally less than that needed for project evaluation (Lee and Walsh 1992).
- Effective SEA requires a level of cross- and inter-departmental communication and co-operation with which our present political administrators are not familiar (Cuff and Ruddy 1994). SEA does not fit easily into our current departmental structure of government, and its development will require mechanisms which bring disparate parts of government together to consider impacts and to involve them creatively in the formulation of programs and policies. Such ideas are threatening to line agencies, and this could be one of the largest impediments to effective implementation of SEA. Proponent agencies will be wary of giving potential opponents too complete a perspective of program impacts (Ortolano and Shepherd 1995).
- SEA must be an aid to policy formulation, rather than a post-formulation approach to mitigation, and environmental analysis must therefore be as intrinsic an element of policy formulation and analysis as is economic analysis (Partidario 1996).

The environmental overview process meets each of these imperatives. In fact, it meets nearly all of Partidario's (1996) list of policy framework, institutional, and procedural issues which an effective SEA system would need to address and fits closely with SEA requirements described by Verheem (1992). The environmental overview blurs any distinction between the social and biophysical dimensions of a development activity and sets a clear and integrated base-line of current environmental and social conditions together with a realistic assessment of economics, environment, and both current management and capacity to manage. The range of participants, from different line agencies and non-governmental organizations, brings a range of knowledge and perspectives of the development problem, and provided it is effected in the earliest stages of project/program formulation, is relatively nonthreatening to the proponents. The emphasis is on the whole system in which the development occurs, requiring participants to step outside their disciplinary and departmental bounds. Environmental issues are inherently difficult to compartmentalize, and failure to comprehend the whole system in which the development occurs, focusing only on one sector within that system, means that critical environmental and social issues associated with that development will be neglected. The environmental overview forces the integration of these issues with development considerations. It also provides the right environment for creative and lateral thinking. The assessment can be conducted efficiently and effectively with minimal delay or impedance to the process of development and with minimal use of scarce in-country resources.

The environmental overview assessment tool represents a trade-off between a "coarse" but effective tool to apply frequently to a wide range of assessments and a more "comprehensive" but possibly ineffective tool such as project-based EIA, which is applied infrequently and to a restricted range of activities. It has proved to be a rapid environmental assessment tool for development proposal formulation, and is a mechanism for directly incorporating impacts and opportunities illuminated by this process into the selection and redesign of the proposal. It works at any scale: whether at project-level, program level, or country level. It is applicable to hardware projects or software projects such as capacity building; and it may even be applied to the assessment of policies. Of course, it is no panacea, and requires commitment to the process by the proponent, by environmental agencies, and by government as a whole. No development procedure can work without such commitment.

The environmental overview has evolved from UNDP experience with its own development activities, but may prove to be a versatile tool. Some limited experience has shown that the environmental overview can be used outside of the UNDP system and for a wide range of policy, program, and sectoral analyses other than aid projects. It has the potential to be a model which governments themselves can adopt and adapt as appropriate to their own internal development planning procedures. It should be recognized as a highly appropriate form of strategic environmental assessment for use in developing countries. The environmental overview is at the cutting edge of SEA of programs, plans, and policies in a development context.

Recommendations

The environmental overview is a tool that has been home grown in the development context. It has had little exposure outside of the UNDP system, but it warrants serious investigation and trial by others as a tool that, for small investments of time and effort, can move development programs, plans, and policies towards sustainability.

Beyond application to development aid, and application by developing countries to their own programs, the environmental overview may prove to be the base model on which to construct that elusive SEA tool being sought in developing countries. Its close fit to many of the requirements put forward for effective strategic environmental assessment of programs, sectors, plans, and policies is remarkable. A reverse transfer of technology from the developing to the developed world, perhaps?

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Decision-Scoping

A. L. Brown[1]

Abstract

Creative environmental planning means moving environmental assessments from a negative, adversarial role to a proactive, creative one. This requires altering the procedural requirements and the culture, which currently see Environmental Impact Assessment (EIA) resulting in an encyclopedic, stand-alone report to ones which see it as a dynamic process and an integral tool of development planning. A new starting point is to introduce the concept of *decision-scoping* into the standard scoping phase of environmental assessment. Decision-scoping develops a schedule of all decisions which will be made during the whole of the concept, planning, design, and approval cycle for a particular development, then identifies the information on environmental constraints and opportunities that will be pertinent before each decision-point. This schedule provides the framework around which an efficient, effective, and creative environmental assessment process can be tailored for each development proposal.

Key Words: design, planning, scoping, project management, environmental impact assessment (EIA), timing, tiering, project, program, strategic environmental assessment (SEA), decision making

Two Dominant Characteristics of the Culture of Environmental Assessment

There are both major and minor differences in the way environmental assessments (EA or EIA—the terms are used interchangeably here) are conducted across a wide range of jurisdictions (see Wood 1995). Two characteristics dominate its universal nature: the production of a stand-alone report and its provision of advice to assist in the final decision on the proposal. That environmental assessment will be a major player in the final decision, and that the appropriate input to this final decision is the report at the end of the assessment, are fundamental notions underlying the form and content of the environmental assessment process as we practice it today. This paper suggests that these notions are seriously flawed and may now be impeding, rather than promoting, environmental assessment as a creative environmental planning tool for the next century. We need to look anew at some of our basic practices in environmental assessment.

The Focus of Environmental Assessments on "The Report"

The report (or, more assertively, the statement) emanating from environmental assessments is still regarded as the heart of the process. This view, of the report being an end in itself rather than *a means to an end*, is strongly ingrained in the culture of environmental assessment. It is fostered by most current legislation, with content and format often prescribed. The encyclopedic document as the end-product of the assessment process has been much criticized (New Zealand Commission on the Environment

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1985), but the report remains so fundamental to our current practice that few could envisage an assessment being satisfactorily concluded without one. It is interesting to note that legislation has much more to say about what is to be presented in the report than about how that information is to be derived, or about how the findings are to be used. The environmental assessment report is the mechanism for conveying all the information from the assessment to the decision makers and other interested parties—and invariably the sole mechanism.

The origin of this emphasis on the report as an end in itself is indisputably the U.S. National Environmental Policy Act, 1969:

> ...all agencies of the Federal Government shall...include in every recommendation or report on proposals for legislation and other major Federal actions...*a detailed statement*...on the environmental impact of the proposed action...[emphasis added].

As Nelson (1993) somewhat overstates: "The enormously cumbersome EIS process that has grown out of a single sentence in NEPA has ballooned far beyond what the authors envisioned." One can only speculate as to what forms of environmental assessment practice might have been in place today if, instead of "a detailed statement...on the environmental impact of...proposed actions," NEPA had required *effective minimization of environmental effects of proposed actions* or, perhaps, *environmentally sustainable actions*. Ferester (1992) proposed changes to NEPA which would employ a variety of more active legal requirements such as a mandate to select alternatives which were more environmentally favorable, or a mandate that adverse effects be mitigated, but these have not been implemented. The environmental assessment report as an end rather than a means has been a particularly enduring principle for nearly thirty years.

Environmental Assessment and Decision-Making

There would be little disagreement that the objective of environmental assessment in its first twenty-five years has been, and remains, the provision of environmental information to decision makers. Most commentators (Clark 1984; Hollick 1986; Caldwell 1988) have cited objectives such as:

- to provide decision makers with information about the beneficial and adverse social and environmental effects of projects, programs, plans, and policies, or
- to ensure that environmental factors are able to be considered alongside economic, technical, and political considerations in decision making.

This is the theory underlying environmental assessment. But perhaps it is more its defining myth, as there is very little analysis of exactly to what decisions—and how—environmental assessment is able to contribute. Common understanding would be that environmental assessment is intended to influence the *big decision*—that of whether the project or program should proceed or not, but a close examination is likely to show that the *big decision* is invariably influenced much more by factors other than the environmental assessment itself. This paper introduces the concept of the *ongoing nature of decision making* as part of project planning and design, and the appropriate relationship between it and environmental assessment.

EIA Is a Passive Activity

The primacy of the final report in environmental assessment leads one to the conclusion that the requirements of environmental assessment are such that it be done rather than anything be done by it (Brown and McDonald 1995). The work is completed when the report is completed and passed on to decision makers for their action. This role is essentially passive. While legislation is usually clear in specifying when environmental assessments are required, what is to be reported, and the time frame in which they should be completed, the formal processes generally do not require too much more from the assessor than the role of observer, recorder, and proposer of mitigation strategies. There is generally no requirement for interaction between different players in the course of the assessment process, for resolution of issues, nor even for implementation of environmental assessment outcomes. Findings rarely have more than advisory status either for the proponent or for the decision-maker, and neither is bound to action—certainly not within the assessment process itself. Mechanisms outside the process, for example conditions attached to development approval under a town planning scheme, generally have to be called upon to implement environmental assessment findings.

This essential passivity pervades much of the environmental assessment process and has shaped much of the dominant culture among its actors.

However, in the decades in which environmental assessment has been serving its passive advisory role, there has been, in practice, the steady development and evolution of an informal but more active role for environmental assessment. Environmental practitioners and project planners alike often have found it expedient and logical to incorporate environmental design changes into projects while they are still being planned rather than waiting until the assessment report was completed—the latter invariably unavailable until it becomes too late to make design changes. This is the dynamic process by which design changes to achieve mitigation have become incorporated into a project well before anything was submitted for approval. According to many practitioners, major and minor environmentally related changes continue to be achieved in projects as a result of design changes won by active involvement of the environmental assessment team in the design process. This should not be left to chance. Mechanisms which can achieve this interaction need to be fostered, but such interaction fails to be fostered by our formal environmental assessment procedures.

Changing the culture of environmental assessment requires a radical reconsideration of the relationship between the environmental assessment process and the development process to ensure a fully active, rather than a passive, role for environmental assessment. It also requires new tools which focus on the timing and nature of *all* decisions which will have to be made during the complete cycle of the project conception, planning, design, and approval.

The Relationship Between the Assessment Process and the Development Process

The Parallel and Independent Model

The concept of a stand-alone environmental analysis carried out distinctly from the planning and design of the project or program still dominates as the model in most formal administrative environmental assessment requirements. This is most appropriately described as an independent, essentially parallel, model.

The parallel and independent model has inherent structural weaknesses. First, it keeps assessment aloof from direct involvement in the project planning process, forcing it to operate largely in a vacuum. Though the environmental consultants are likely to have been selected and paid by the proponent, environmental reports are prepared, at least in theory, at arm's length from the proponent and those planners and designers directly involved in development of the proponent's project. Such separation may facilitate (an illusion of?) independence in the preparation of the environmental report, but does little to foster good environmental planning of the project. Second, it results in the environmental information becoming available too late in the project planning process (see Clark 1984; Wright and Greene 1987; Beanlands 1988; Wood and Djeddour 1992;

Therivel et al. 1992). The failure of the parallel and independent assessment model to ensure the appropriate timing of the information flow between the environmental assessment and the design process is a critical, if not fatal, failing in our current processes. Graybill (1985) is succinct on this, suggesting that much environmental assessment practice is involved in dispute creation, not resolution:

> ...a change that might have been well received and initiated on the basis of a ten-minute telephone call to the project manager, earlier in the feasibility stage, may be vigorously opposed at the end of the design stage or in the construction stage, even if supported by field studies and thick reports.

The model is inherently ineffective. Ortolano and Shepherd (1995) note that project proponents will not undertake an EIA until after a project is well-defined and likely to be approved, and suggest that project proponents would effectively be irrational to do otherwise. Legislatively forcing proponents to take EIA seriously still does not necessarily force them to consider environmental factors early, or continually, as a project evolves.

Staged, or tiered, assessments represent a partial response to this problem of disconnection between the environmental assessment and the project planning and design. Partial reporting of environmental effects using some form of initial environmental effects report and schemes where broad environmental overviews of alternatives are followed by more detailed assessment of a chosen alternative, have all been suggested and, in some cases, implemented. The use of tiering is increasing in the U.S. federal EIA system (Wood 1995), but while methods such as this have been widely suggested, their limited uptake in most administrative systems suggests that there are practical problems in their implementation.

The Integrated Model

Environmental assessment needs to metamorphose from a *report* into a *process* in order to integrate fully with project planning and design. To do this, the parallel, non-interacting assessment and design activities have to be re-conceptualized as two completely interacting activities in an integrated model. This is not a new idea. Many authors have flagged the necessity of interactions (for example, Bailey and Saunders 1988; Institution of Professional Engineers of New Zealand 1985; Brown and McDonald 1990), but there appear to be difficulties in making these suggestions fit real planning and design processes. While few would disagree that an integrative approach is desirable, little practical guidance to project managers and environmental managers exists on how to move away from the conventional parallel independent model of assessment. It is suggested below that *decision-scoping* provides an important key.

Dynamic interaction between environmental assessment and project planning and design is not just neglected by many procedural systems but actually hindered by them. Environmental administrative systems, particularly those in developing countries, have resulted in focusing most energy on getting the assessment document right, or sufficiently accurate, to pass the approval hurdle, rather than on getting the project itself environmentally correct. This encourages proponents to view environmental assessment mainly as a perfunctory step in obtaining project implementation permits. That integrated models have not been taken up is clear when one finds, in almost any set of requirements for conducting environmental assessment, little or no mention of the project or program design activity itself. The procedural charts for conducting environmental assessment always set out in detail the role to be played by administrators involved in project authorization, the role to be played by those conducting the assessment, and sometimes the role to be played by the affected community; but pay either little or no attention to the role, information needs, or requirements of the planning/design professionals (engineers, planners, resource managers, etc.) responsible for the project itself. Even in a recent ten-page article on "The EIA Planning Process," in which the emphasis was on the means by which knowledge is structured and applied for decision-making purposes (Lawrence 1994), there is no mention of the needs of the planning/design professionals.

What Is Needed to Make the Integrated Model Work?

If the advantages of an integrated model are obvious—and they have been for at least a decade (Clarke 1984; Hollick 1986)—but have yet to be implemented, it is likely that we lack the tools to achieve integration.

Recently, Brown and Hill (1995) have proposed a new approach to this problem. The approach builds on the concept of environmental assessment as input to decision making, but recognizes the reality that the *big decision* is only one of a multitude of decisions in project development which requires environmental input. Their approach recognizes the even more acute reality that most of these decisions are made early in the project planning and design stages (see Table 1).

Decision-scoping

Brown and Hill's (1995) methodology is a natural extension to the standard EIA scoping exercise. *Decision-scoping* requires:

- an understanding of the entire processes of planning, design, approval, and implementation and documentation of the complete range of *decision points* in these processes
- a focus on *all* these decisions—by the proponents, the designers, the approval authorities—and ascertaining the nature and timing of the environmental input required to appropriately inform the decisions
- design of the timing and content of the environmental assessment around these decision points.

Planning and design are neither linear activities nor incoherent black boxes. The art of design can be conceptualized as a long series of iterations in which successive concepts are continuously tested against objectives and constraints until judgments (decisions) can be made about fixing some specific element of the design. Designers make decisions, some small, some large, as the planning proceeds—they choose sites, refine project layout on the chosen site, they choose plant size, building bulk and height, technology, timings, raw material and energy sources, waste treatment and disposal, transport modes, and construction techniques. Their decision making occurs as a series of small steps which gradually build momentum and importance. As this proceeds, options are foreclosed. Flexibility exists until the decision-points are reached in the design process, but beyond each of these—momentum, budgets, deadlines, interdependencies and personal commitment of the planner/designer—in turn harden and form an ever increasing obstacle to change or revision. By the time the early design stage is passed, most of the project dimensions are frozen and there is virtually no such thing as a minor change in a major design constraint.

Designers arrive at their decision-points using all the information that is available to them at the time. No option should be foreclosed without the designer being in possession of the environmental information pertinent to that particular decision. Decision-scoping is the essential tool which enables this to happen.

Brown and Hill (1995) point out that decision-scoping can be effected by initially developing a schedule of all the decision-points during the whole of the project planning, design, and approval continuum. It must then identify exactly what environmental information will be germane for the decisions to be reached at these decision-points. It is essential that decision-scoping should be undertaken by the managers of both the project design and environmental assessment teams. Together they should identify the nature of the information required before each decision-point and the time required to gather and assess this information. It is quite likely that the environmental assessment manager will pose environmentally based questions to the project planner, which will result in new planning activities requiring specialist environmental input and new decision-points not anticipated by the project planner. For example, it might be pointed out that “you cannot make that decision at that time, because we will not have enough ecological information from field studies by then” or “that choice between alternatives will have to wait because it will foreclose options too soon in the environmental assessment process.” The project manager may think that a certain choice is straightforward, say, on engineering grounds, and will be unaware that an apparently simple choice translates to major differences in environmental effects. Equally, the project planner may convey that suggested environmental studies will take too long in that certain decisions are going to have to be made sooner—in which case the assessment work will have to be redesigned to provide the information sooner by devoting more resources to it. Evers and de Jongh (1985) note that there is just as much of a need for a *requirement-stream* from the decision-maker to the analyst as there is for an *information-stream* from the analyst to the decision-maker. The decision-scoping exercise has to be a two-way street in which both environmental assessment and project planning activities will have their timing and content adjusted. Brown and Hill (1995) demonstrate how this could work.

Table 1 is a simplistic but illustrative example of the relationship between project planning and design, EIA, and decision making. Whether those responsible for EIA and decision making like it or not, proponents invest a lot of time and effort into their proposals before they get to the EIA stage. What this paper recognizes is that this is rational behavior on the part of proponents. Instead of environmental assessment procedures seeing this as a black box, decision-scoping is the tool for environmental assessment to look into this box and identify the sequence of decision points that will occur. Once the decision points are recognized, it is much easier to see how the EIA analysis must be structured, and both the nature and the timing of the critical environmental information that must be available to the planning and design process *before* each of the decision points is reached. Brown and Hill (1995) provide a more detailed example of the decision-scoping process. What is clear is that decision-scoping should occur on a case by case basis, with a relevant environmental analysis and assessment program designed for each proposal.

Codification of a decision-scoping phase, and subsequent interactive activity between environmental assessment and project planning teams, need not necessarily diminish the independence of environmental assessment in its passive role. Final documentation of environmental impacts can still be prepared for overall approval and for the public.

Decision-Scoping and Strategic Environmental Assessment

Brown and Hill (1995) developed the decision-scoping tool with project-based EIA in mind, but it will have equal application in Strategic Environmental Assessments (SEAs). As Lee and Walsh (1992) point out, “SEA, to be effective, should be integrated into existing procedures at key decision-making points for policies, plans and programmes.” Sheate (1992) makes similar observations, as does much of the recent

Table 1

Project Planning and Design
as a Black Box and as a Series of Decision

Project conceived by Proponent	
PROJECT PLANNING AND DESIGN SEEN AS A BLACK BOX	**PROJECT PLANNING AND DESIGN SEEN AS A SERIES OF DECISIONS** * proponent decides project feasible on financial estimates * proponent decides to design pipeline rather than rail * most economical corridor selected for detailed design * preferred route in corridor selected on engineering basis * proponent selects least-cost construction techniques
Proponent receives advice as to whether EIA is required. EIA IS PREPARED	
DECISION MAKERS USE EIA IN PROJECT APPROVAL	

literature on SEA. Just as decision-scoping is the analysis tool to define the links between decision making and required environmental input for a project, it can also provide the essential methodological key in a field which currently lacks a methodology, as to how to insert environmental dimensions into program, policy and plan development, and even whole sectors of government.

Conclusions and Recommendations

The integration of environmental assessment and design has been neglected, if not hindered, by formal EIA procedures, dominated as they are by the requirement to produce a stand-alone document for decision makers. In most jurisdictions the historical baggage of procedures and formats for EIA studies and reports are unlikely to be effective or efficient when the intent is to use the environmental assessment as an active design tool. We are locked in history with our current approaches to environmental assessment, and we need to evolve present processes—and the cultural inertia surrounding them—away from reactive negativity towards proactive creativity.

Projects are planned and designed in a series of iterations where successive concepts are continuously tested against objectives and constraints until judgments can be made about fixing some specific element of the design. Flexibility exists until decision-points in the planning/design/approval process are reached, but beyond each of these, in turn, there is an ever-increasing obstacle to change or revision. Decision-scoping should be applied in all EIAs to develop a schedule of all the planning and design decisions which will have to be made during the life of the project planning and approval cycle, so that it identifies what information on environmental constraints and opportunities will be pertinent before each decision-point. The environmental assessment manager can then creatively design the assessment process around this framework.

The decision-scoping exercise has to be a two-way street in which both environmental assessment and project planning activities are likely to have their timing and content adjusted, and should be undertaken jointly by the managers of both the design and environmental assessment teams. Decision-scoping needs to be applied as the essential step to avoid the encyclopedic, misdirected, and expensive environmental assessment studies of the past and the problem of inappropriate content and timing of environmental input. The nature and timing of the environmental assessment study is determined; the questions which the environmental assessment is to address are clearly prescribed; and the project planning time frame is altered to ensure that options are not foreclosed prior to the availability of the required information from the environmental assessment study.

The new tool should be used to provide the framework for the integration of the environmental assessment with all development activities, not just for projects but equally for policies, plans, and whole sectors.

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NEPA and Ecological Management: An Analysis with Reference to Military Base Lands

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Abstract

This paper examines how the National Environmental Policy Act (NEPA) can be employed to advance new federal ecological management policies on military base lands. Ecological management contemplates natural resource policies framed at appropriate spatial and temporal scales to meet legitimate human needs while protecting and restoring the integrity of ecosystem resources and processes. NEPA processes can be used to: (1) define a shared ecological management vision, (2) promote inter-jurisdictional coordination, (3) employ comprehensive scientific information, (4) promote biodiversity conservation, (5) prepare large scale environmental assessments, (6) target achievable solutions, and (7) facilitate adaptive management strategies. By integrating NEPA and Sikes Act planning obligations, which apply to military base lands, Department of Defense (DoD) officials can promote ecological management policies and improve NEPA compliance while still fulfilling military preparedness obligations.

Key Words: adaptive management, biodiversity conservation, ecosystem management, environmental law, military lands, National Environmental Policy Act (NEPA), programmatic environmental impact statements, Sikes Act, tiering, watershed management

Introduction

Ecological management involves managing lands, ecosystems, and watersheds on a large scale over long periods of time. The federal government has adopted an ecosystem management approach (Congressional Research Service 1994; Interagency Ecosystem Management Task Force 1995a). Some federal agencies have embraced watershed approaches to restore and protect aquatic ecosystems and resources (Adler 1995). The DoD has endorsed an ecosystem management approach for its military base lands (Goodman 1996). Both approaches share the idea that resource management decisions should be made within scientifically—rather than geopolitically—defined boundaries, considering the full range of resource values and impacts. The National Environmental Policy Act (NEPA) (42 USC § 4321-61) is assuming a major role in these new federal ecological management initiatives.

This paper will examine how NEPA can be used to facilitate federal ecological management efforts, with a focus on DoD military base lands. The paper will: (1) define the concept of ecological management in terms of seven general principles, (2) review

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NEPA and the Sikes Act as they relate to ecological management, (3) examine how NEPA can be employed to advance ecological management principles, and (4) conclude with specific recommendations for integrating NEPA into ecological management.

Ecological Management Principles

Historically, natural resource and environmental policy has focused on the impacts of individual decisions on a relatively discrete area or narrow range of resources. More recently, federal and state agencies have begun to realize that such narrow approaches fail to account for the cumulative ecological impacts of a wide range of actions over large areas and long periods of time (National Research Council 1992). As a result, the federal agencies have embraced the related concepts of ecosystem management and watershed management to ensure the ecological integrity of the nation's land and water resources (Congressional Research Service 1994, Proceedings, Watershed 1996; U.S. Environmental Protection Agency 1996). Both concepts, which can be merged together as ecological management, are oriented toward maintaining healthy, diverse, and sustainable ecological systems.

The concept of ecological management is best understood and defined in terms of seven general principles (Interagency Ecosystem Management Task Force 1995a; Adler 1995; Moote et al. 1994; Grumbine 1994). The principles are:

- Common ecological management goals should be socially defined through a collaborative vision process that involves all interested participants and that incorporates ecological, economic, and social considerations (Moote et al. 1994; Cortner et al. 1994).
- Given that most ecosystems and watersheds transcend conventional geopolitical boundaries, ecological management requires coordination among federal, state, tribal, and local governmental entities as well as collaboration with other interested parties (Shannon 1993; U.S. General Accounting Office 1994).
- Ecological management policies and decisions should be based upon integrated and comprehensive scientific information that addresses multiple rather than single resources (Moote et al. 1994; Grumbine 1994).
- Ecological management seeks to maintain and restore biodiversity and ecosystem integrity (Grumbine 1994; Keiter 1994).
- Ecological management involves management at large spatial and temporal scales that correspond to ecosystems and watersheds (Naiman 1992; National Research Council 1992).
- Given the finite nature of public funds and other resources, ecological manage ment enables agencies to engage in careful targeting to select achievable solutions and to allocate resources efficiently (Adler 1995).
- Ecological management requires an iterative, adaptive management approach to account for changing goals and values and new scientific information concerning ecological conditions (Interagency Ecosystem Management Task Force 1995a; Lee 1993).

In short, ecological management contemplates natural resource policies that are framed at appropriate spatial and temporal scales to meet legitimate human needs while protecting and restoring the integrity of underlying ecological resources, systems, and processes. The DoD has generally embraced these principles in its approach to ecosystem management (Department of Defense Instruction 1996; Office of the Undersecretary of Defense 1994).

Ecological Management, NEPA, and the Sikes Act

Basic NEPA Provisions and Requirements

The National Environmental Policy Act of 1970 (NEPA) requires that an Environmental Impact Statement (EIS) be prepared for every "major Federal action significantly affecting the quality of the human environment" (42 USC § 4332). An EIS must contain five elements: (1) the environmental impact of the proposed action, (2) the unavoidable adverse effects of the proposed action, (3) alternatives to the proposed action, (4) the effect of the proposed action on the environment's long term productivity, and (5) irreversible and irretrievable commitments of resources resulting from the proposed action (*Id.* § 4332 [C]). The Council on Environmental Quality (CEQ) has issued NEPA implementing regulations that are binding on federal agencies (40 C.F.R. § 1500.3; *Andrus v Sierra Club*, 442 U.S. 347 [1979]).

The Supreme Court has consistently interpreted NEPA to be a procedural statute that requires agencies to produce fully informed decisions and to disclose the environmental impacts of a proposed action (*Robertson v Methow Valley Citizens Council*, 490 U.S. 332 [1989]). Federal agencies, however, are not obligated to choose the least environmentally harmful alternative (*ID*). Courts reviewing EIS challenges should not defer to an agency "without carefully reviewing the record and satisfying itself that the agency has made a reasoned decision based on its evaluation of the available information" (*Marsh v Oregon Natural Resources Council*, 490 U.S. 360, 378 [1989]). As a result, courts have enforced NEPA's procedural requirements and often enjoined agencies to reassess the environmental consequences of a proposed action (see *Marble Mountain Audubon Society v Rice*, 914 F.2d 179 [9th Cir. 1990]; *Bob Marshall Alliance v Hodel*, 852 F.2d 1223 [9th Cir. 1988]). Thus, NEPA has become a principal means for ensuring environmentally accountable decisions.

Programmatic EISs and Tiering

The programmatic EIS and related tiering process are an effective NEPA compliance procedure that can be used to achieve ecological management goals. Although NEPA does not mention the programmatic EIS, the Supreme Court has endorsed the concept: "When several proposals for... actions that will have cumulative or synergistic environmental impacts...are pending concurrently before an agency, their environmental consequences must be considered together" (*Kleppe v Sierra Club*, 427 U.S. 390, 410 [1976]). The CEQ regulations encourage federal agencies to tier their EISs and thus support the programmatic EIS concept (40 C.F.R. § 1508.20). Federal agencies can utilize programmatic EISs to look beyond the impacts of a particular project, focusing instead on a policy or program to implement several similar projects (Porterfield 1994, Cooper 1993). However, the decision of whether and how to prepare a programmatic EIS is a matter of agency discretion (*Conservation Law Foundation of New England, Inc. v Harper*, 587 F.Supp. 357, 364 [D. Mass. 1984]; 40 C.F.R. § 1508.28[b]).

A programmatic EIS can save an agency time and resources. It allows agencies to "eliminate repetitive discussions of the same issues and to focus on the actual issues ripe for decision at each level of environmental review" (40 C.F.R. § 1502.20). Issues adequately addressed in a programmatic EIS need not be revisited in NEPA documents addressing subsequent, site specific actions, which may be "tiered" on the initial programmatic EIS (40 C.F.R. §§ 1502.20, 1508.28; *Jones v Lynn*, 477 F.2d 885 [1st Cir. 1973]). Federal agencies often "tier" less complex environmental assessments to earlier programmatic EISs when reviewing specific project proposals. The DoD's NEPA regulations encourage the use of tiering (32 C.F.R. Part 188, Encl. 1, § D.5).

The Sikes Act

The Sikes Act, (16 USC § 670a et seq.) establishes natural resource planning and management requirements for DoD installations. The Act authorizes DoD "to carry out a program of planning for, and the development, maintenance, and coordination of, wildlife, fish and game conservation and rehabilitation" pursuant to cooperative plans developed jointly with the Department of the Interior and appropriate state agencies (*Id.* § 670a[a]). Cooperative plans must provide for fish and wildlife habitat improvements or modifications, range rehabilitation to support wildlife, off-road vehicle traffic control, and protection for threatened or endangered fish, wildlife, and plants (*Id.* § 670a[b][1]). Preparation of these plans will require NEPA compliance (Army Environmental Center Conservation Branch 1996). Plans must be reviewed "on a regular basis, but not less often than every 5 years" (*Id.* § 670a[b][2]). The plans may include cooperative agreements with states, local governments, nongovernmental organizations, and individuals (*Id.* § 670c-1).

Like NEPA, the Sikes Act primarily establishes procedural mechanisms for sound natural resources planning and management. Unlike NEPA, the Sikes Act also establishes a general substantive standard for natural resources management on military reservations. Military lands must be managed for "sustained multipurpose uses" and "public access" that is not inconsistent with the military mission of the reservation (*Id.* § 670a-1[a]) DoD regulations specify how the Sikes Act will be interpreted and implemented, including specific requirements for Integrated Natural Resources Management Plans (INRMPs [*Id*]).

Employing NEPA as an Ecological Management Tool

For federal agencies, the NEPA process can be a vital component of an ecological management approach (Interagency Ecosystem Management Task Force 1995b). Careful implementation of NEPA, including the use of programmatic EISs and tiering, can ensure that the seven principles of ecological management are incorporated into agency policies and decisions.

Creating a Shared Vision

Ecological management goals should, to the extent possible, be socially defined through a shared vision process incorporating ecological, economic, and social considerations. NEPA and its implementing regulations provide a framework for involving affected interests, the public, and other federal, state, and local agencies in the decision-making process. It enables agency officials to identify principal points of agreement and to design responsive ecological management policies.

The CEQ regulations require agencies to "[m]ake diligent efforts to" involve the public throughout the NEPA process (40 C.F.R. § 1506.6). Agencies are required to give public notice of the proposed action (*Id.* § 1506.6[b][3]). An EIS must be prepared early "so that it can serve practically as an important contribution to the decision-making process and will not be used to rationalize or justify decisions already made" (*Id.* § 1502.5) The public and other agencies must be involved in project and EIS scoping (*id.* § 1501.7) and in draft, final, and supplemental EISs (*Id.* §§ 1502.9, 1502.19). The agency has a duty not only to invite comments, but to consider and respond to them fully (*Id.* §§ 1503.1, 1503.4). Agencies are also required to hold public hearings where appropriate (*Id.* § 1506.6[c]).

However, NEPA has some limitations as a tool for developing ecological management objectives. First, simply going through the motions of the scoping and comment process will not ensure a shared vision between the public and the agency. It may reveal several competing views. A true shared consensus among diverse interest groups may require the use of procedures or dispute resolution techniques beyond those mandated for NEPA compliance. Second, NEPA's consultation and public involvement requirements cannot override an agency's mission or other statutory requirements. While considering the views revealed in the shared vision process, the agency will ultimately have to make a policy decision consistent with its statutory obligations. In the case of DoD lands, this means reconciling the shared vision process results with primary military training and preparedness responsibilities (See 32 C.F.R. § 190.4[b]).

Facilitating Interagency Cooperation and Consultation

Cooperation among agencies is a key to successful ecological management and to resolving transboundary resource problems. NEPA can help facilitate communication and interagency coordination. NEPA requires agencies to "consult with and obtain the comments of any Federal agency which has jurisdiction by law or special expertise with respect to any environmental impact involved" (42 USC § 4332[C]). When two or more agencies are involved in geographically proximate activities, the CEQ regulations provide for designation of "lead" and "cooperating" agencies to collaborate in the environmental analysis process (40 C.F.R. §§ 1501.5 to 1501.6). Moreover, federal agencies with legal jurisdiction or special expertise in an area have a duty to comment on an EIS, or to make an affirmative decision that no comment is needed (*Id.* § 1503.2). However, the lead agency retains ultimate responsibility for the EIS and for the final decision (*Id.* § 1501.7[a][4]).

Interagency consultation is also important between federal and nonfederal agencies. The CEQ regulations require lead agencies to discuss "[p]ossible conflicts between the proposed action and the objectives of Federal, regional, State, and local (and in the case of a reservation, Indian tribe) land use plans, policies and controls for the area concerned" (40 C.F.R. § 1502.16[c]). According to the regulations, "[w]here an inconsistency exists between [State or local plans or laws and the proposed action] the [EIS] should describe the extent to which the agency would reconcile its proposed action with the plan or law" (*Id.* § 1506.2[d]). In the case of DoD lands, the Sikes Act contemplates the preparation of cooperative management plans with the Department of the Interior and the states (16 USC §§ 670a, 670c-1; 32 C.F.R. Part 190). However, the Sikes Act also provides that the facility commander retains ultimate control over whether to adopt cooperative planning recommendations (32 C.F.R. Part 190, App. B.3.c).

Integrated and Comprehensive Scientific Information

Ecological management requires comprehensive resource inventories and evaluations, identification of potential sources of ecological impairment, and development of protection and restoration strategies. NEPA also requires and promotes the use of good science to improve environmental decision making (42 USC § 4332[2][A]; 40 C.F.R. § 1502.6). Under the CEQ regulations, agencies must use "high quality" information, "[a]ccurate scientific analysis," and "expert agency comments" (40 C.F.R. § 1500.1[b]). Where new information is essential to make a "reasoned choice among alternatives," it must be obtained unless the cost of doing so is exorbitant or the means to obtain it are not known (*Id*. § 1502.22). However, agencies are not required to use any particular scientific theory or mode of scientific analysis (*Sierra Club v Marita*, 46 F.3d 606 [7th Cir. 1995]; *Oregon Environmental Council v Kuntzman*, 817 F.2d 484 [9th Cir. 1987]).

The NEPA process can be a focal point for collecting and evaluating scientific information for ecological management. First, just as ecological management should begin with a comprehensive resource inventory and description, an EIS must include a description of the "affected environment" (40 C.F.R. § 1502.15). By defining the "affected environment" for NEPA purposes according to natural boundaries and by using programmatic and tiered EISs that address cumulative impacts within these boundaries over time, agencies can improve both NEPA compliance and ecological management (Hunsaker 1993). Second, just as ecological management relies on a careful analysis of potential sources of impairment within a region, NEPA requires a complete evaluation of the environmental consequences of proposed agency actions, including indirect, secondary, and cumulative impacts (40 C.F.R. §§ 1502.16, 1508.7, 1508.8, 1508.25). Third, just as ecological management requires full evaluation of alternative protection and restoration strategies, NEPA requires agencies to consider a full range of alternatives to the proposed agency action, including a "no action" alternative.

The Sikes Act also encourages the use of comprehensive and coordinated scientific information. The DoD can enter into cooperative plans with the DOI and states (16 USC §§ 670a, 670c-1) which can include coordinated research and data-gathering efforts (32 C.F.R. Part 190, App. A.5.d). The Sikes Act also requires that plans be developed, monitored, reviewed and revised by natural resource managers with professional training (16 USC § 670a-1[b]); 32 C.F.R. Part 190, App. A.3). Moreover, Integrated Natural Resource Management Plans must include "current inventories and conditions of natural resources" (*Id.*, App. A.5.c).

Maintaining and Restoring Biodiversity

Ecological management seeks to maintain and restore biodiversity and ecosystem integrity. Although NEPA imposes no enforceable substantive mandates on agencies, it provides a tool that agencies can use to achieve biodiversity goals (Bear 1994) and to comply with substantive environmental requirements arising from other statutes, regulations, and treaties. One of NEPA's purposes is to "prevent or eliminate damage to the environment and biosphere...." (42 USC § 4321). NEPA also expresses a national environmental policy that aspires "to create and maintain conditions under which man and nature can exist in productive harmony..." (*id*. § 4331[a] and to "preserve important historic, cultural, and natural aspects of our national heritage...." (*Id*. § 4331[b][4]). To achieve these goals, federal agencies should seek to minimize impacts on biodiversity and ecosystem integrity. As part of the EIS process, federal agencies should (1) prepare complete environmental inventories that identify all species, habitats, and other elements of ecosystem structure that are at risk from a proposed action, and (2) rigorously evaluate alternatives and mitigation strategies to enhance rather than impair biodiversity and ecosystem health (Council on Environmental Quality 1993, U.S. Environmental Protection Agency 1994a, U.S. Environmental Protection Agency 1994b).

In the case of DoD lands, biodiversity and ecosystem conservation is promoted, if not required, under the Sikes Act and its implementing regulations. The Sikes Act requires management for the "sustained multipurpose use" of natural resources consistent with the military mission (16 USC § 670a-1[a][1]. The term "sustained" implies the preservation of biological and other renewable resources. The Sikes Act also requires INRMPs to address fish and wildlife habitat improvements, range wildlife benefits, traffic control for wildlife protection, and habitat improvements and protections for threatened and endangered species (16 USC § 670a[b][1]). Moreover, DoD regulations provide that "watersheds and natural landscapes, soils, forests, fish and wildlife, and protected species shall be conserved and managed as vital elements of DoD's natural resources program" (32 C.F.R. § 190.4[c]).

Managing at Large Spatial and Temporal Scales

Ecological management involves management at large spatial and temporal scales that correspond to ecosystems and watersheds. Under NEPA, the use of programmatic EISs and tiering enables agencies to plan on large geographic and time scales (Myslicki 1993). Geographically, tiering allows agencies to prepare programmatic EISs for spatially broad areas, such as "regional or basin-wide program statements" (40 C.F.R. § 1508.28[a]). Later proposals for localized actions can then be assessed for new issues, incorporating the programmatic EIS by reference (*Id*). Temporally, tiering can be employed by preparing an initial EIS at an early stage of a project. At later stages, when other issues are ripe for decision, further NEPA analysis can then be prepared and tiered to the earlier EIS (*Id.* § 1508.28[b]).

Cumulative impacts analysis is also an important dimension of large scale management. When an agency proceeds by a site-specific rather than programmatic EIS, the NEPA regulations require the consideration of a wide range of related and cumulative impacts. In defining the scope of an EIS, agencies must consider "connected actions;" actions which have "cumulatively significant impacts," and "similar actions" that should be evaluated together, including actions with common geography (*Id*. § 1508.25[a]). Under the CEQ regulations, agencies are required to consider the incremental impacts of their actions as well as the actions of others over a broad geographic scale and extended time periods (*Id.* § 1508.7; National Research Council 1992; Keiter 1990).

Targeting to Select Achievable Solutions

Faced with increasingly limited resources, agencies must employ their time, money, and personnel wisely to achieve the best results. Ecological management allows agencies to target the most important problems within a defined region, and to prioritize the best protection and restoration strategies. NEPA's rigorous requirement that agencies identify and consider a full range of alternatives, including alternative mitigation strategies, is a useful method for implementing a targeting strategy. Under the Sikes Act, the DoD is obligated to engage in similar targeting: INRMPs should include "schedules of activities and projects" and "priorities" (32 C.F.R. Part 190, App. A.5.C).

Adaptive Management

Ecological management requires an iterative, adaptive management approach to account for changing goals and values, as well as new information concerning ecological conditions. NEPA can be used to promote such an adaptive management approach (Cooper 1993). First, programmatic EISs can be written to anticipate more precise or changed scientific data, analytical techniques, or alternate management strategies. The programmatic EIS can include a feed-back loop based upon an ongoing monitoring program (Cooper 1993). Subsequent, tiered EISs can then be prepared to account for new information, scientific and engineering advances, shifting values and priorities, and other factors. Second, EISs can be supplemented to reflect newly acquired information, often through a tiering process (40 C.F.R. § 1502.9[c]; 490 U.S. 360 [1989]). Relatedly, the Sikes Act requires that INRMP plans be reviewed on an ongoing basis, and at least every five years (16 USC § 670a[b][2]. NEPA can be employed during this review process to address new information or changed circumstances.

Agencies should not view the NEPA process as an obstacle to adaptive ecological management. Because preparation of an EIS is often a lengthy and difficult process, the natural tendency is to consider the matter closed once a decision is made and to proceed with project implementation. Since the courts generally defer to agencies in deciding when a supplemental EIS is needed (*Marsh v Oregon Natural Resources Council*, 490 U.S. 360 (1989) agencies may avoid preparing a supplemental EIS unless one is legally required. However, if a wide range of alternatives and project strategies (i.e., anticipating new information and conditions) is considered when the EIS is initially written, then new NEPA compliance may not be required. Moreover, the tiering process—particularly the use of a programmatic EIS—can be used to ensure an initial comprehensive analysis that includes monitoring programs. Alternatively, the NEPA process might be augmented with a representative advisory or management committee with authority to implement project changes. Although such a committee may not always obviate the need for supplemental NEPA compliance, it should minimize project delays and reduce controversy.

Conclusions and Recommendations

NEPA and the Sikes Act can be jointly employed to establish and implement ecological management programs on DoD lands and in DoD natural resource programs. Integrated implementation of the two laws can produce more efficient planning for DoD installations and better management of ecological resources. By employing sound principles of ecological management, DoD agencies can also achieve better and more efficient compliance with environmental planning and decision-making statutes, including NEPA and the Sikes Act. However, because NEPA and the Sikes Act primarily establish a process for natural resource management and planning, agency decisions must still meet the minimum requirements in independent federal, state, or local laws and regulations.

Several conclusions emerge from this analysis. First, sound implementation of NEPA participation opportunities and Sikes Act cooperative programs can help develop the shared goals and interagency relationships that are essential to good ecological management. Additional consensus-building through the use of other tools, such as advisory committees and alternative dispute resolution methods, may also be necessary. Second, ecological management, NEPA, and the Sikes Act should be used collectively to coordinate comprehensive resource inventories, ecosystem health and biodiversity assessments, analyses of ecological impairment sources, and reviews of protection and restoration strategies. Third, to promote ecological management goals and to avoid implementation delays, NEPA compliance should be accomplished as broadly as possible from a geographic and temporal perspective. This includes: the use of programmatic and tiered impact statements based on ecosystem or watershed boundaries; the inclusion of all relevant federal, state, and local agencies as well as other nongovernmental participants throughout all phases of NEPA compliance; and identification of the widest possible range of project alternatives, along with accompanying restoration and mitigation strategies. Fourth, adaptive management goals can be achieved under NEPA through the use of supplemental EISs to address major changes in conditions, impacts, or project proposals, and under the Sikes Act through the use of cooperative management committees. In sum, the DoD should consider further institutionalizing coordinated compliance with NEPA and the Sikes Act, including preparation of joint programmatic environmental impact statements and INRMPs.

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18

Use of Geographic Information Systems in Impact Assessment

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Abstract

Geographic Information Systems (GIS) are computer systems used for storing, retrieving, analyzing, and displaying spatial data. Considering the spatial nature of many environmental and socio-economic impacts, GIS can be a very important tool in all impact assessment stages and may even act as an integrating framework for the whole impact assessment process. However, the widespread application of GIS in impact assessment still remains to be realized because of drawbacks such as the time and money necessary to invest in GIS, and the lack of data available in an appropriate form that can be loaded directly into the systems. This paper reviews case studies and key developments, and discusses several advantages and disadvantages of using GIS for impact assessment.

Key Words: geographic information systems (GIS), environmental modeling, spatial data, data quality and accuracy, data accessibility

A Quick Introduction to GIS Relevant to Impact Assessment

Geographic Information Systems (GIS) are spatial databases in which the information is geo-referenced, that is, all data have a known location on the earth's surface. Some of the benefits of GIS arise exactly from this database structure, which allows for spatial information to be stored, integrated, and analyzed in a more powerful and efficient way than was ever possible using paper maps. For this reason alone these systems are now being applied to a wide variety of disciplines and applications which all have in common an interest in or concern with the *spatial dimension*. GIS have been used to investigate everything from services provision, site suitability, facilities management, market analysis, risk assessment, fire-risk simulation, emergency planning, epidemiological research, and transport routing to the inventory, analysis, modeling, and management of the environment.

A key reference on GIS is the book by Maguire, Goodchild, and Rhind (1991), which addresses both methodological issues (from the nature of spatial data and data structures to spatial analysis and data accuracy) and landmark applications (including soil information systems and development of environmental databases). Each chapter offers a detailed review of the field and is an invaluable source of GIS-related literature (a revised edition is planned for 1998). Many other shorter books summarizing GIS methodology and applications are also available, for example, Aronoff (1989), Cassettari (1993), and Raper (1993b). A constantly updated source for new GIS literature is the *GISWorld* web page (http://www.gisworld.com/publications.html).

In order to function properly, GIS require five main components: *hardware*, *software*, the *people* working with the system (or "liveware"), the *organizational structures* where these systems are implemented, and the *data*. These last three compo-

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nents are the most crucial for nearly all GIS applications, and are the ones that will ultimately determine the success of GIS within an organization such as an environmental consultancy carrying out impact assessment (Aronoff 1989; Huxhold and Levinsohn 1995).

The availability and quality of spatial data are particularly important to the use of GIS for impact assessment. Data require a high time investment and are the most expensive components of a GIS system to acquire (between 50% and 80% of the total cost of the project, according to Huxhold and Levinsohn 1995). Moreover, it is data quality which will ultimately determine the value of the results obtained. Accuracy issues and data quality checks are extremely important (Goodchild and Gopal 1989; Thapa and Bossler 1992), especially bearing in mind that environmental statements may turn out to be used as legal documents (Epstein 1991).

The true potential value of GIS lies in their ability to *analyze* spatial data successfully. It is their spatial query and spatial analysis functions that distinguish them from other types of information systems. If GIS are only being used as sophisticated map-making tools, they are being under-utilized and the user would probably be better served by a less complex and cheaper system. For this reason this review gives more emphasis to the analytical potential of GIS for impact assessment rather than to the presentational capabilities (which are also considerable).

Before addressing the application of GIS to impact assessment, this chapter reviews the use of GIS for environmental applications in general and for environmental modeling in particular. Key issues about the use of spatial data in GIS, such as data quality and accessibility, are also considered. References related to the use of GIS for environmental applications are relevant for particular impact assessment stages, such as ecological and landscape assessments, pollution modeling, and environmental monitoring. The review on the use of GIS for impact assessment at the end of this chapter goes a step further by investigating how GIS can contribute to the impact assessment process as a whole.

The Use of GIS for Environmental Applications

The advantages of using GIS for environmental applications have been widely documented. These range from inventory and monitoring applications to environmental modeling and management. Even what has been called “the world’s first GIS”—the Canada GIS developed back in 1966—had an environmental use. These GIS were created to assess the land capability of the whole of settled Canada in a more efficient way and so propose the possibility of rehabilitating marginal farms (Coppock and Rhind 1991).

There are now a series of books dedicated to the use of GIS for environmental applications. Haines-Young, Green, and Cousins (1994) cover the use of GIS for landscape ecology. Heit and Shortreid (1991) deal with GIS applications in natural resources. Kovar and Nachtnebel (1993) encompass the growing field of the application of GIS in hydrology and water. Mitchener, Brunt, and Staff (1994) review state-of-the-art issues in the management and analysis of environmental information using GIS at a variety of scales (from ecosystems to global scales).

The development in the use of GIS for research in the environmental field has grown to such an extent that some authors have argued for a new “subfield within physical geography and environmental science which can be characterized as *Environmental GIS* (Raper 1993a). This is reiterated by Goodchild, Steyaert, and Parks (1996) who suggest that “a new research discipline involving fundamental scientific issues is being created by the synthesis of geographic information systems and environmental modeling.”

GIS for Environmental Modeling

Two of the most important publications in this area are Goodchild, Parks, and Steyaert (1993, 1996)—both are based on presentations made at the International Conference/Workshop on Integrating GIS and Environmental Modeling, an important bi-annual conference series. Part of the research effort in this field has been devoted toward moving GIS beyond a traditional approach that deals mainly with a two-dimensional and static representation of the world to a three-dimensional representation and the handling of the temporal dimension (see also Peuquet 1994; Price and Heywood 1994; Raper and Kelk 1991). Other key work focuses on the development of new data models (e.g., object-oriented models) which are more suitable for representing and modeling complex environmental phenomena (Raper and Livingstone 1995).

There are two main approaches of using GIS for environmental modeling (Goodchild, Steyaert, and Parks 1996): either the modeling is done linked to but *outside* the GIS or the modeling is done *within* the GIS. In the first case, the modeling is done by environmental modeling software that uses the GIS as a source of information for the variables and parameters of the model (the link between the two being done via a computer program usually written by the user). The GIS are used to perform either *pre-processing functions* for preparing the spatial data to run in the model (e.g., coordinate transformation, projection change, clipping to fit study area, resampling) and/or *post-processing functions* for result presentation (e.g., map production, visual analysis of residuals). Even if the GIS are not being used directly for the modeling, this approach has been found to have many benefits in terms of speed, accuracy, and flexibility when manipulating data into a format appropriate to run in a model (see João and Walsh 1992).

The "external" modeling approach is the most common. As in many cases of so-called "GIS environmental modeling," the models are run parallel to the GIS application and the GIS themselves is not the modeling platform. Running environmental models *within* a GIS would entail "enhancing the current capabilities of GIS so that they can perform the role of a modeling environment or language, obviating the need to couple GIS and modeling software" (Goodchild, Steyaert, and Parks 1996: 313). This is considered by Goodchild, Steyaert, and Parks (1996: 313) to be "an ambitious goal, in part because much of the impetus for the development of GIS over the past decades has come not from environmental modeling but from less sophisticated applications in the areas of facilities management and inventory. The idea that GIS might be a tool to support sophisticated spatio-temporal modeling is still far from being broadly accepted."

Spatial Data Issues Related to the Use of GIS for Environmental Applications

While discussing new methodological developments, it is also important to consider data problems and constraints which might affect the performance and quality of these methods (see, for example, Clark 1993; Fisher 1991). The effective use of GIS is closely tied with understanding the nature of spatial data and how data quality might affect the end results. Goodchild, Steyaert, and Parks (1996) deal with a wide range of data-related issues, including the availability of data, the design of environmental databases, methods for interpolation and resampling, problems of accuracy and related issues of error propagation in modeling, and the sensitivity of model results to data models and data quality.

Of these data issues, a key question is the source scale or resolution of the spatial data to be used, and how this detail level will affect the end result. The smaller the scale, the less detailed and more generalized the data will be, and this in turn affects the results obtained from GIS in different ways. Map generation can, for example, alter the results of measured lengths and areas, and cause shifts of features, affecting their positional accuracy. These can in turn alter the results obtained from typical GIS map manipulations such as overlay operations (João 1995).

There are other data-related problems with particular relevance to the environmental field (see João 1994). There can be difficulties associated with feature definition and identification. The boundaries of features are often considered to be well defined and sharp when often there is considerable blurring of boundaries, that is, they are in fact “fuzzy” boundaries (Burrough and Frank 1996). Despite these problems, GIS can, when care is taken, give sufficiently accurate and powerful results.

The Use of GIS for Impact Assessment

Many authors have suggested that GIS are a very useful tool for impact assessment (e.g., Guariso and Page 1994; Schaller 1990; World Bank 1993; World Bank 1995) and have predicted that they will be used increasingly in the future. For example, in their book on methods of environmental impact assessment (EIA), Morris and Therivel (1995) propose that in the future “EIA methods are likely to rely increasingly on GIS and computer models,” and that we will observe an increase in the use of much larger databases. However, despite this acknowledged potential, and in contrast to the wealth of literature on the use of GIS for environmental applications in general, the actual use of GIS for impact assessment has been sparingly documented. The bibliographic database GEOBASE (between January 1990 and May 1996) contains 31,246 publications related to the environment, 4,560 related to GIS, and 941 publications on impact assessment. In contrast, only fifty-six publications mentioned both GIS and impact assessment (i.e., approximately 6% of the impact assessment papers).

There may be several reasons for this apparent scarcity of literature on the use of GIS for impact assessment. For many researchers and practitioners, GIS are relatively new and complex, and only now might they consider investing time and resources on this technology. For example, a recent survey on the use of GIS for impact assessment by environmental consultants found that most respondents only first became involved with GIS in the late 1980s (João and Fonseca 1996). In addition, much written evidence on the use of GIS for impact assessment can be classified as “gray literature” (i.e., it is only available as internal reports of consultancies or government offices, or in proceedings of small national conferences) and, therefore, is difficult to obtain.

Examples of the Use of GIS for Impact Assessment

In their survey on the use of GIS for impact assessment, João and Fonseca (1996) found that GIS have been applied to a wide range of different impact assessment projects (thirty-five different types of projects in total). The most common applications were the impact evaluation of roads, pipelines, housing developments, coast and flood protection works, dams, tourism-related projects, ports, and power lines. The survey also found that GIS are currently being used by environmental consultancies for *all* impact assessment stages, from the preliminary stages of screening and scoping to the final stages of monitoring and auditing.

A series of different impact assessment studies can be found in the literature wherein GIS played a central role in the impact assessment. Jensen and Gault (1992) described the impact assessment of a new 1,140 kilometer power line from southern Idaho to Las Vegas. GIS were also used to identify alternative power line corridors for an area of 97,800 square kilometers. Appelman and Zeeman (1992) described how their established procedure for calculating the impact of highways in the Netherlands was adapted to GIS with great success. Wagner (1994) described the work carried out to evaluate the socio-economic and environmental impact of one of the largest automobile facilities in Europe. Schaller (1992) reported on the measurement of the impact of the new Munich

International Airport. Asabere (1992) discussed the assessment of the impacts of the mining industry in Ghana.

The experience of the U.S. National Environmental Policy Act (NEPA) in using GIS for impact assessment is described in Hildebrand and Cannon (1993). Three particular impact assessment studies that used GIS are presented: (1) route suitability analysis and impact assessment of routing a highway through the Tonto National Forest, (2) assessing the environmental impacts of a proposed nuclear waste repository at Yucca Mountain, Nevada, and (3) determining the impact caused by visitor use of the Big Cypress National Preserve, Florida.

Despite these successful applications of GIS, some authors discuss the need to appraise the limitations of using GIS for impact assessment, particularly bearing in mind the constraints on environmental consultancies of tight deadlines and budgets (McAulay 1991; Vaughan 1991). Vaughan (1991) even suggests the development of a methodology for defining where GIS can or cannot help in an impact assessment project.

Key Developments and Research Issues on the Use of GIS for Impact Assessment

Many of the GIS applications for impact assessment use only a few basic GIS functions such as measurement of lengths and areas, map production, buffering, and the classic overlay operation. Map overlay has, of course, a long tradition in environmental planning and impact assessment, having been used since the 1960s (McHarg 1969). Compared with the cumbersome manual process of overlaying transparencies, the overlay analysis is made much more powerful through the use of GIS. It is more accurate, more flexible, there is no restriction on the number of overlays that can be applied, new maps resulting from the overlay operation are automatically produced, and different computations can be easily and quickly made. The following review endeavors to focus on developments which go beyond these basic functions.

One of the most interesting new developments on the use of GIS for impact assessment is the recent work by Antunes et al. (1996). They approach GIS as an *integrating framework* for the whole impact assessment process. This includes the development of an interface for project definition and management of environmental baseline information; interfaces for the use of simulation models for impact prediction and their representation on a spatial basis; and a new impact evaluation methodology relying on the use of spatial information relative to the impacts. Using the information stored in the GIS, this new methodology computes a set of impact indices based on impact magnitude, spatial incidence of the impacts, and the sensitivity or importance of the affected resources (e.g., population, soils, ecosystems). The authors conclude that this new methodology increases the objectivity of the impact evaluation stage. While in support of this “holistic approach” in the use of GIS for impact assessment, Nutter, Charron and Moisan (1996) argue that, in order to gain “full value” from GIS, they should be employed throughout the life cycle of a project, from project design and preliminary environmental assessment to monitoring and post-operation evaluation.

Another interesting development in the use of GIS for impact assessment is the system EAGLE (Andersen 1996). EAGLE is a Management Information System based on GIS, and was developed for monitoring *and* assessing the environmental impact of the construction of a massive tunnel and bridge between Denmark and Sweden. For example, if during a dredging operation a spill occurs, leading to a level of pollution above a particular threshold, the system not only records this value but it then determines whether the spill can be expected to cause damage to the environment (for example, by simulating if it will spread to more sensitive coastal areas). The results can be accessed by the Feedback Centre that controls the running of EAGLE and also by any other interested parties. They will be able to constantly follow the decisions being made and supervise the procedure. The full system is expected to be finished in August 1996, when it will also include access to satellite photos and video sequences of the sea bed.

Rodbell (1993) discusses the merits of using GPS (Global Positioning System) combined with a GIS. The author found that this approach circumvented the problem of a lack of digital data, allowing maps to be updated directly in the field and to any level of detail desired. The GPS/GIS approach made it easier to accurately map wetland areas and sensitive plant species, thereby ensuring appropriate mitigation. The author claims that "using GPS/GIS mapping, the field crew mapped 5,000 acres of detailed study area and 40,000 acres of general study area in approximately two weeks" (Rodbell 1993: 56).

Other examples of ground-breaking research projects which aim to improve the impact assessment process through the use of GIS are the following:

- the use of genetic algorithms for generating and evaluating alternative sites within GIS (Pereira and Antunes 1996)
- the incorporation of multimedia capabilities (e.g., interactive manipulation of sound, video, and still images) into GIS in order to create more realistic and effective environmental decision support systems for impact assessment (Fonseca et al. 1995)
- development of open spatial decision support systems via the Internet, and, using GIS, one which could eventually be used for supporting remote public consultation in impact assessment (Carver, Blake, and Turton 1996)
- use of expert systems together with GIS as a vehicle to incorporate subjective-technical judgment in the impact assessment process (Lein 1992)
- using GIS in order to improve visual impact assessment (Kidner, Dorey, and Sparques 1996).

Finally, some authors have suggested that GIS are especially suited to cope with more global and challenging areas of environmental assessment, such as cumulative impact assessment (Johnston et al. 1988; Parker and Cocklin 1993) and strategic environmental assessment (SEA) (e.g., Sadler and Verheem 1996). A very interesting pilot project in the use of GIS for SEA is the work by the U.K. Royal Society for the Protection of Birds (Bina, Briggs, and Bunting 1995). The authors determined the impact of transportation networks on nature conservation for the whole of Europe in order to evaluate transport policy in the European Union. GIS proved to be an invaluable tool for this project. It is possible that in the future GIS will be even more useful in strategic planning (that is, in connection with policy, program and plan preparation) than in the environmental assessment of individual projects.

Advantages and Disadvantages of Using GIS for Impact Assessment

The reasons why GIS is such a valuable tool in impact assessment (see Eedy 1995; João and Fonseca 1996) can be summarized as follows. First, there is the ability of GIS to perform spatial analysis and modeling, which in turn can contribute to better impact prediction and assessment. Second, there is the ability of GIS to efficiently store, organize and easily update spatial digital data relevant for impact assessment studies. This allows the integration of different kinds of spatial information previously unrelated, to easily obtain new results for changing conditions, and to compare or integrate data from different impact assessment studies. Finally, there is the ability of GIS to provide good visual display capabilities which lend themselves well to explaining development plans or alternatives to the public.

In contrast to these advantages, there are current problems related to GIS technology which are preventing GIS from being used more widely in impact assessment or to their full potential. According to João and Fonseca (1996), the following are the most critical problems or disadvantages felt by environmental consultants (in order of importance):

- the long time required to set up the GIS, build the database, and input and process the relevant data
- initial start-up costs for hardware, software, and data collection and conversion to digital form
- lack of data in digital format
- the high requirements in terms of training and technical expertise
- data error and accuracy problems
- user-related errors when using computer-based GIS techniques rather than more conventional, manual methods
- weak analytical capabilities for particular purposes
- lack of GIS awareness.

Despite these problems, it is incumbent upon all researchers in the field of environmental science to at least be aware of the power of GIS. Although GIS might not be always be relevant to a particular impact assessment project, the ability of GIS to analyze and present spatial data successfully (and its potential contribution for the evaluation of the growing area of SEA) will probably mean that GIS will be more extensively used for impact assessment in the future. However, opportunities remain for further improving the way GIS analytical tools are being used for impact assessment. It will be necessary for better links between environmental models and GIS to be developed, for new and better GIS functions dedicated to impact assessment to be designed, and for an increased awareness to grow among impact assessment practitioners of the potential of GIS.

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19

Post-Project Impact Assessment and Monitoring

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Abstract

Environmental impact assessment (EIA) is the identification, prediction, and evaluation of impacts. Monitoring closes the loop. It transforms EIA from a one-time pre-project document to a continual assessment of impacts. This article reviews current methods and trends in post-project impact assessment and monitoring. Monitoring is important for many reasons, including: to audit mitigation measures, to refine impact assessment methods, and to improve project outcomes through adaptive environmental management.

Key Words: environmental monitoring, post-project audits, environmental impact assessment

Introduction

Post-project impact assessment and monitoring (PPIAM) is a "beneficial and logical capstone" of environmental impact assessment (Culhane 1993: 66). This is underscored by the Council of Environmental Quality (CEQ) regulations for monitoring and enforcement of mitigation measures (CEQ 1987). In addition, the Army requires monitoring for their environmental mitigation programs (U.S. Army 1988). EIA practitioners widely agree that monitoring is one of the most important issues facing them today (Ensminger and McLean 1993).

Monitoring is important for several reasons. First, it determines whether agencies implemented the promised mitigation measures and whether these measures were effective. Second, monitoring compares the actual effects of a project to its predicted effects. Third, monitoring improves project outcomes through adaptive environmental management. Despite monitoring's importance, relatively little attention is paid to the actual effects of a project after an EIA document is completed. However, without systematic follow-up and feedback, the EIA process becomes merely an administrative hurdle rather than a means to produce real-world environmental benefits.

This paper examines the state-of-the-art methods and future trends for post-project impact assessment and monitoring. First, a brief background on monitoring is given. Then comes a review of methods for PPIAM which provides practical steps for implementing a monitoring program. Recent applications of monitoring methods and programs are examined next. Finally, recommendations are provided on how to improve PPIAM so that it can help to fulfill the potential of EIA.

A clarification of terms related to post-project impact assessment and monitoring is in order. "Environmental monitoring" refers to the set of activities that provide chemical,

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physical, geological, biological, and other environmental, social, or health data required by environmental managers (U.S. Environmental Protection Agency (EPA) 1986). "Environmental audits" are to statutorily verify or systematically review an EIA document (Culhane 1993). "Environmental postaudits" determine the actual impacts and outcomes of projects that were subject to an EIA (Culhane 1993). "Post-project analysis" concerns life-cycle environmental management and environmental studies during project implementation (Economic Commission for Europe (ECE) 1990). In this article, the term "post-project impact assessment and monitoring" refers broadly to the collection of activities above.

Background

How common is monitoring?

Despite monitoring's widely recognized importance, it is not a well-established activity in the U.S., for several reasons:

- Environmental monitoring data are expensive and difficult to collect. Agency funding and staffing may be limited. To compound this problem, agencies usually collect monitoring data from scratch, even though there may be opportunities to use data from previous projects. Improved information transfer and coordination would allow agencies to share and reuse monitoring data. However, existing monitoring data are not without complications. Extant data may be difficult to interpret, assess, and integrate with other sources of information (Canter 1996).
- Monitoring can be time consuming. Project proponents usually want to design and build quickly so that a project can be operational in a short time. Little consideration is given, unless required, to monitoring baseline or future conditions. This "not on my watch" attitude sacrifices long-term cradle-to-grave considerations for short-term project goals.
- Agencies lack guidance. Existing regulations do not provide clear procedures or methods for monitoring. Numerous environmental laws have created a confusing and fragmented monitoring framework. Monitoring requirements may be included, or are assumed to be included, in other regulations or at other levels of government. As a result, monitoring activities are duplicated, uncoordinated, or not conducted.
- Agencies are under little legal pressure to conduct monitoring. Even though the CEQ regulations call for monitoring, the courts have not traditionally held for the plaintiff seeking to ensure mitigation monitoring. It remains to be seen whether regulations for monitoring are judicially enforceable (Culhane, Friesema, and Beecher 1987).
- Agencies may fear self-incrimination through monitoring. Agencies have little incentive to collect data that could be used against them by regulatory bodies as a basis for fines.

What are the benefits of monitoring?

Notwithstanding the above challenges, the case for monitoring is compelling. The benefits fall in three general categories: to audit mitigation measures, to refine impact assessment methods, and to improve project outcomes through adaptive environmental management.

First, a clear benefit of monitoring is to ensure compliance with mitigation measures. All too often, an EIA document promises mitigation measures that are never carried out. Through monitoring, an agency can evaluate the effectiveness of mitigation measures and refine the measures before it is too late to prevent or ameliorate unacceptable impacts.

Second, monitoring can improve forecasting capabilities. EIAs tend to do best in predicting the direction, but not necessarily the magnitude, of change associated with major direct impacts. Indirect and cumulative impacts are predicted less accurately, if at all. PPIAM provides information that could be used to verify predicted impacts and thus refine impact prediction techniques in EIA. This requires that the monitoring data correspond with the environmental parameters in the EIA document.

Third, monitoring can improve project outcomes through adaptive environmental management (AEM). AEM deals with uncertainties by continuously modifying management practices (Carpenter 1996; Holling 1978). Many post-project impacts may not be anticipated. Monitoring allows an agency to continually adapt, evaluate, and improve impact management activities (Leistritz and Chase 1982).

Who benefits from monitoring? The case for monitoring is more convincing if those who bear the costs also reap the benefits. An agency that invests in a monitoring program will benefit not only from improved mitigation measures but from greater knowledge on impact forecasting methods and improved project outcomes.

Methods for Post-Project Impact Assessment and Monitoring

Two challenges confront methods for PPIAM. First, as noted earlier, monitoring is not a well-established activity. Second, there are no prescribed or even generally accepted monitoring methods. In light of these challenges, this section reviews the most common methods for PPIAM: baseline monitoring, effects (or impacts) monitoring, and compliance monitoring. Other methods include scientific monitoring, management monitoring, enforcement monitoring, and effectiveness monitoring. The next section presents "how-to" guidance for implementing these methods in a monitoring program.

- *Baseline monitoring* is the "measurement of environmental variables during a representative pre-project period to try to determine existing conditions, ranges of variation, and processes of change" (Sadler and Davies 1988). It is the most widely implemented monitoring method because baseline data (descriptions of the affected environment) are required in an EIA document. Problems with baseline monitoring are that it is often "undertaken without clearly defined objectives" (Beanlands 1988). An agency could waste resources on data collection without understanding why data are collected.
- *Effects or Impact Monitoring* is "the measurement of environmental variables during project construction and operation to determine the changes which may have occurred as a result of the project" (Sadler and Davies 1988). Effects monitoring requires close attention to environmental changes because the perceived change must be clearly attributable to the project. It requires establishment of causal relationships between action and effect through "reference" and "treatment" monitoring stations. Effects monitoring and baseline monitoring are connected because "the usefulness of effects monitoring depends to a great extent on the existence of data against which to measure change (which is) usually the product of baseline studies" (Wilson 1992).
- *Compliance monitoring* makes sure that a project is in compliance with relevant laws (e.g., the Clean Air Act). Impact analysts regard this monitoring type as not only linked to baseline and impact monitoring but also an extension of them (Harrington 1996). It "takes the form of periodic sampling and/or continuous

measurement of levels of waste discharge, noise, or similar emission, to ensure that conditions are observed and that standards are met" (Harrington 1996). A distinction between compliance and effects monitoring is that compliance monitoring does not necessarily involve measurement of environmental changes (Wilson 1992).

- *Scientific monitoring* checks EIA accuracy and explains errors (Wilson 1992). It seeks to explain the reasons for any variance between EIA predictions and the impacts that actually occurred.
- *Management monitoring* determines whether recommended mitigation measures were undertaken and were effective (Wilson 1992).
- *Enforcement monitoring* ensures that mitigation is being performed as described in the EIA document (Canter 1996).
- *Effectiveness monitoring* measures the success of the mitigation measures. This is a scientific, quantitative investigation; qualitative measures are not acceptable (Canter 1996).

Procedures for Implementing PPIAM

How Can We Use these Methods for PPIAM?

Interestingly, while the literature advocates a systematic integration of PPIAM in EIA, most of the published studies do not follow this rule. Rather, most studies just spot-check predictions in a wide array of documents (e.g., Culhane, Friesema, and Beecher 1987; Buckley 1991). A *monitoring program* is necessary to systematically incorporate PPIAM methods with EIA. Harrington's review (1996) of fifteen monitoring programs finds that lack of funds for monitoring is a major problem. One solution would be to withhold project funding until monitoring is built into the project (Harrington 1996). This, in fact, is prescribed in the U.S. Army's Regulations (U.S. Army 1988).

One of the most widely cited set of procedures for implementing a monitoring program is given in Marcus (1979). Each step requires a justification for data collection efforts to make sure that resources are not spent on non-essential activities. There are two phases.

Phase I develops the monitoring system: (1) define action, (2) predict impacts, (3) identify and define major impacts to be monitored (These first three steps are carried out in the EIA process), (4) obtain participation of agencies in development of a monitoring system, (5) identify agencies' authority for controlling or mitigating impacts, (6) define monitoring objectives, related to the anticipated impacts of the action, (7) determine data requirements: impact indicators, frequency and timing of data collection, monitoring collection areas, method of data collection, data type and storage format, data analysis method, (8) review data requirements in terms of monitoring objectives, (9) determine data availability, (10) conduct feasibility evaluation, and (11) define the monitoring system in terms of its goals, impacts to be monitored, and data to be collected.

Phase II implements and operates the monitoring system: (1) implement monitoring system, (2) review, define, create, and fund agency and institutional responsibilities for monitoring, (3) collect data, (4) analyze data to determine relationships between activities and impacts, (5) evaluate impacts (6) consider impact trends and rates of change, impacts that have reached critical levels, impacts that have exceeded legal limits, and effectiveness of mitigation measures, (7) respond to impacts: use agencies' authorities to reduce and prevent impacts, (8) document changes, and (9) record impact levels and effectiveness of mitigation measures in reducing impacts.

Another set of procedures for implementing a monitoring program is given in Spellerberg (1991). This framework includes nine general steps: (1) define monitoring objectives, (2) determine sites for monitoring, (3) ensure sites are related to the objectives, secure for the duration of monitoring, and representative of the types of impacts, (4) make plans to document data, (5) arrange for data collection and storage, (6) select the variables to be monitored, (7) develop indices that relate to the objectives and gather data and conduct baseline surveys, (8) consider field measurements as well as data from other sources, and (9) analyze and present the data. Notably, even though this framework was developed for ecological impact monitoring, it can be adapted to other types of impact monitoring.

One innovative method for PPIAM is the impacts-backward approach (Wilson 1992). This method compares predictions from environmental impact statements (EISs) to project outcomes. The focus is on improving the NEPA process, not just on environmental science. The method is as follows: (1) select a group of EISs and projects to evaluate, (2) consider EISs that have much in common, such as one type of project or geographic area, (3) identify major impacts of the projects (4) look for any environmental effect that can be traced directly to a project, (5) determine if the EIS predicted the impacts, and (6) prioritize impacts for detailed investigation, (7) determine the extent to which the EIS is wrong, (8) assess the type and magnitude of uncertainties causing the EIS prediction errors, and (9) use the lessons learned to improve the NEPA process.

Another approach that deserves attention is public participation in mitigation monitoring. The project proponent (and the environmental agency) make arrangements with stakeholders for monitoring the mitigation measures. Local citizens periodically check the effectiveness (and implementation) of mitigations and provide feedback. This agreement could be made explicit in the EIA document. The benefits include improved compliance and effectiveness of mitigation measures; reduced enforcement burden on the environmental agency; cooperation between project proponent and public; and citizen involvement with project that instills a feeling of ownership. This approach has been recommended in the U.S. Army's Chemical Demilitarization program (Bradbury et al. 1994).

Monitoring Programs

In addition to the U.S. Army's efforts, several U.S. federal agencies have adopted monitoring programs. The U.S. Department of Energy (DOE) has developed a "mitigation action plan" with a tracking program to ensure that mitigations are, in fact, carried out. In the case of a mitigated FONSI, the project proponent is barred from implementing the action until the mitigation is in place (DOE 1992). The U.S. Forest Service (USFS) requires three different levels of monitoring for their plans: implementation monitoring (to make sure that activities are carried out as designed in the plan); effectiveness monitoring (to determine whether outcomes and objectives in the plan occurred); validation monitoring (to refine or correct data or assumptions or models) (USFS 1988). The U.S. Department of the Interior's Bureau of Land Management, the Park Service, and the Fish and Wildlife Service have planned for monitoring programs (U.S. Bureau of Land Management 1994). The White House has created an Interagency Ecosystem Management Task Force to use monitoring to meet a policy goal of ecosystem management (Joy 1995 as cited by Carpenter 1996).

Some international agencies also require monitoring programs. For example, environmental assessment reports for World Bank projects require a monitoring plan that specifies: the type of monitoring, the responsible agency, the cost, and the necessary resources (World Bank 1989). The International Organization for Standardization (ISO) is creating an international movement towards monitoring. The ISO 14001 is a proposed, voluntary, worldwide standard for environmental management systems and environmental auditing. Market pressure may induce companies to be certified under ISO 14001, even in the absence of legal requirements.

Recommendations

How can PPIAM fulfill its potential?

First, strengthen and clarify requirements to ensure that agencies will follow through on post-project monitoring. Enforceable monitoring programs need to be built into EIA documents. PPIAM is an essential link between the short-term "get the project approved" emphasis of EIA documents and the long-term environmental policy objectives of NEPA. The commitment to impact assessment does not end with a document, but with more environmentally-sound outcomes.

Second, create incentives for monitoring. Because PPIAM is embroiled in fears of self-incrimination, project proponents may not easily accept what appears to be a blind faith underwriting of ecological research (Carpenter 1996). Work with project proponents to demonstrate the benefits of PPIAM. Devise regulations so that they do not discourage the collection and use of information. If agencies encourage self-auditing, devise a credible immunity policy.

Third, encourage the reuse and sharing of monitoring data and information, both intragency and interagency. One way to accomplish this may be through the Internet and the World Wide Web. Data sharing can reduce the costs of collecting monitoring data, and it can encourage coordination between and within agencies.

Fourth, expand the scope of monitoring in time, space, and strategic decision making. Plan monitoring programs in the pre-project stages of EIA, rather than wait until the post-project stage (even though that is when monitoring occurs). Monitor at the ecosystem level and consider cumulative impacts, rather than individual, site-specific impacts. Include monitoring at the level of strategic decisions—policies, plans, and programs—rather than at just the individual project level. EIA should be viewed as an iterative, adaptive, life-cycle process. Monitoring within this panorama will help to promote the goals of environmental impact assessment.

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Triggering and Technical Quality of Environmental Impact Assessment: The Tourism Testbed[1]

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Abstract

For EIA (Environmental Impact Assessment) to contribute effectively to development planning, it must be triggered for appropriate development applications and be carried out at a sufficient level of technical quality to allow development decisions to be made on the basis of adequate environmental information. The tourism sector provides a particularly good testbed for these aspects of EIA because tourism developments are commonly of medium scale, often clustered, and involve relatively predictable impacts. Tests conducted at local government, state-wide, and national scale for a decade and a half of tourism development in Australia showed that EIA has generally only been triggered by mandatory provisions, either at local government level, as in Queensland (Qld) after 1991, or in New South Wales (NSW); or at State government level as in Queensland prior to 1991. Where EIA at local government level has been discretionary, as in Queensland prior to 1991, it has generally been avoided. The technical quality of tourism EIA across Australia has been relatively poor. Baseline studies have been sketchy, testable impact predictions few, and monitoring programs low in power or non-existent. Tourism EIA could be improved by more stringent triggering provisions, more stringent assessment requirements, and more focused scoping.

Key Words: tourism, EIA, predictions, baseline, triggering, monitoring, quality, legislation

Introduction

All functional EIA frameworks contain three essential components, at least conceptually: triggering, technical assessment, and development decision. Most frameworks also contain a fourth component, post-development monitoring and feedback.

Effective triggering mechanisms are an essential component. EIA will not work if it is not used. In most countries and jurisdictions, triggering processes include both legal

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and political components, and there are different levels of EIA with different triggering criteria and thresholds. Triggering mechanisms need to be efficient, so that EIA is carried out at an appropriate level for potential developments which are likely to have significant environmental impacts, but not for those which are not (Buckley 1992; Warnken and Buckley 1995a).

Technical assessment covers all components of EIA from triggering to decision, whether carried out by proponents, consultants, government agencies, or the public. This includes scoping, baseline studies, impact predictions, mitigation and monitoring plans, public submissions and hearings, and review and assessment by regulatory bodies. Technical assessment is the core of the EIA process, and while it is not the only component, technical assessment of adequate quality is essential for the EIA process as a whole to function effectively.

Most evaluations of EIA seem to have focused on processes, such as public participation; or on outcomes, such as the accuracy of impact predictions (Vanclay and Bronstein 1995). There seem to have been relatively few detailed evaluations either of triggering processes or of the technical quality of EIA documents. Here we present such evaluations for one industry sector in one nation over a fifteen-year period.

The tourism industry provides an excellent testbed for such evaluations. Most tourism developments are of medium scale. Some are subject to EIA and some are not, and the cutoff threshold provides a good test of triggering mechanisms. Most are in relatively undisturbed natural environments where high quality baseline assessments are both feasible and important. Most involve straightforward engineering activities and waste streams whose impacts should be predictable with a relatively high degree of confidence. Tourism developments are often clumped, with a high potential for cumulative impacts, which are an important feature in evaluating both triggering mechanisms and technical assessment.

The Australian tourism industry provides a particularly valuable testbed. It has three levels of government—local, state, and federal. EIA can be triggered by planning or development applications at any level, and may be carried out at either state or federal level or both. There are significant differences in policies, legislation, and administrative procedures between states, and these provide an additional avenue to test both triggering mechanisms and technical quality.

Here, therefore, we present an analysis of triggering and technical quality in EIA over a decade and a half of development in the Australian tourism industry.

The Australian Tourism Sector and EIA Legislation

Tourism and travel are part of the largest and fastest growing industry sectors, both in Australia and the world. Worldwide, the tourism sector generated over $0.3 trillion in 1995, or 11% of world Gross Domestic Product (GDP), and employed 11% of the total workforce. In Australia, the tourism sector employed 7% of the Australian workforce and generated $44 billion in 1994-95, or 7% of GDP. Tourism contributes 13% of Australian export earnings, substantially more than traditional export commodities such as manufacturing, coal, wheat, or wool (Drew 1996).

Australia has had legislative frameworks for formal EIA at the federal and state level since the mid-1970s. Federal EIA is only triggered where a Commonwealth approval is required under one of the Commonwealth Constitutional Heads of Power. For tourism developments this has typically included those in Commonwealth Territories and those in or adjacent to World Heritage areas, though there are a number of additional Heads of Power which could potentially be relevant. Development proposals in the Great Barrier

Reef Marine Park, for example, have been assessed by the Great Barrier Reef Marine Park Authority (GBRMPA), a federal agency, under the *Environment Protection (Impact of Proposals) Act* 1974 (Commonwealth).

There have been considerable differences between states (Buckley 1991). In Queensland, for example, EIA for different types of development was provided for under different legislation. Large tourism developments were often approved under special-projects legislation, but most applications for tourism development were considered under the *State Development and Public Works Act* 1971-1981, which had limited and entirely discretionary provisions for environmental assessment. Until 1991, development and rezoning applications to local government authorities (LGAs) were subject to the *Local Government Act* 1936 (Qld), which had even more limited provisions for EIA. Since mid-1991, the majority of small and medium-scale tourism development applications in Queensland have been heard under the *Local Government (Planning and Environment) Act* 1990-91 (Qld), which has more effective provisions for EIA.

Triggering Tourism EIA

Two different approaches were used to test triggering processes. First, LGAs along the entire coastline of the state of Queensland were surveyed using mail questionnaires and telephone interviews, to determine what tourism development applications they had received since 1986, and which of these were subject to EIA. Australia's principal tourism areas are in Queensland. The characteristics of each set were then examined to establish the parameters and thresholds which triggered EIA. Data were obtained from public EIA documents and from relevant local, state, and federal government files and personnel.

Second, a similar but more detailed test was carried out for two selected LGAs, by physically examining all individual rezoning, town planning, and development application files. The LGAs concerned were Albert Shire in Queensland, which had received over a third of all the tourism development proposals in the state over the period considered; and Maclean Shire in New South Wales, as the closest counterpart in a similar natural environment but a different jurisdiction. This approach is very time-consuming and labor-intensive, but enables the outcome of each individual development application to be tracked, whether or not it was subject to EIA and no matter how small the scale.

Almost all tourism development in Queensland is coastal. Apart from Brisbane and Gold Coast cities, where construction of downtown tourist accommodation and facilities has occurred as a part of urban growth, there are thirty-six LGAs along the Queensland coastline. During the decade and a half from 1986 to 1993 inclusive, there were 105 large-scale tourism development proposals in these LGAs. Development proposals were included in this category if they were more than fifteen hectares in area and included tourist accommodation, catering, sporting, entertainment, or shopping facilities. Over one-third of these proposals, forty-two out of 105, were lodged in Albert Shire, a rural and suburban LGA surrounding the city of the Gold Coast. The remaining sixty-three were lodged in twenty-four LGAs along the eastern seaboard of the State.

Overall, 38% of these applications were subject to EIA (Warnken and Buckley 1995a). EIA was required for twelve of the thirteen proposals incorporating both a marina and a golf course, eight of the sixteen with a marina only, twelve of the forty-four with a golf course only, and seven of the thirty-one with neither. These differences are statistically significant at p less than 0.001. Marinas and golf courses had no significant effect on final development consent, but only on the requirement for EIA. EIA was required for all of the largest proposals (greater than 430 hectares), but below that area the triggering effects of development size were indistinguishable from those of specific development components.

Under the *Local Government Act* 1936, LGAs generally did not demand EIA on their own authority, so EIA was carried out only for development proposals which triggered state legislation directly, bypassing LGAs. Marinas triggered EIA directly under State laws relating to harbors, coasts and shorelines, and fisheries, whereas golf courses did not. The *Local Government (Planning and Environment) Act* 1990-91 (Qld) provided directly for EIA in designated development areas, such as coast protection zones; development proponents reacted to the change by stockpiling approvals under the former Act before the later one was promulgated (Warnken and Buckley 1995a). In Queensland, therefore, it appears that discretionary powers for local governments to require EIA under local planning and development approval processes were not effective in triggering EIA in the tourism sector, even though some of the developments concerned involved large areas and major civil and sanitary engineering works.

To test the effectiveness of EIA triggers more rigorously requires information on all development applications and their outcomes, whether subject to EIA or not (Warnken and Buckley 1996). Such data are not published and can only be obtained from LGA files, with expert assistance from long-term LGA staff. They were compiled from Albert Shire in southeastern Queensland, which has received over a third of all tourism development applications in Queensland over the past one and a half decades; and Maclean Shire in northeastern NSW, the adjoining state on the eastern Australian seaboard. Maclean Shire has a similar area to Albert, over 1,000 km^2 in each case, and contains similar environments. Maclean Shire has also encouraged tourism development during the period concerned, and has received similar types of tourism development application.

Each LGA received 3,000 to 3,500 rezoning, town planning, and development applications from 1980 to 1993 inclusive. Of these, 364 applications in Albert Shire were for tourism developments, and 69 in Maclean Shire, which has a much smaller population. For the Albert Shire applications, 234 were town planning consent applications and 112 were rezoning applications. Of the latter, fifty-one were for resorts, and 40% of these were integrated resorts subject to the *Integrated Resort Development Act* 1987 (Qld).

EIA was triggered only for developments greater than fifteen hectares in area or incorporating a marina or golf course. For developments of these types, EIA was triggered for 8/158 applications in the Queensland LGA and 7/19 in New South Wales. These proportions are significantly different at p less than 0.001: the NSW legislative framework (Buckley 1991) is much more effective in triggering tourism EIA. The proportion of projects subject to EIA which were actually approved and constructed, however, was significantly higher in NSW; an effective legal framework for triggering EIA is not a barrier to successful tourism development.

Technical Quality of Tourism EIA

Formal EIA commenced in developed nations such as the U.S., Canada, and Australia during the 1970s. Concerns over its quality and effectiveness led to a series of audits during the 1980s (Buckley 1995). These focused largely on the accuracy of impact predictions as the core component of EIA processes. Typically, however, they found (1) that predictions were rarely couched in testable terms, and (2) that even if they were, baseline and monitoring data were rarely adequate to test them. In addition, predictions generally cannot be tested until developments have been approved, constructed, and operational for several years.

An alternative approach, therefore, is to focus on the technical quality of the EIA document as an indicator of the outcome of the overall EIA process. A high quality EIS does not guarantee that environmental factors will receive adequate consideration in development approval processes, nor that environmental impacts of development will be managed adequately; but these outcomes are even less likely if the EIS itself is of poor technical quality.

Using this approach, criteria for technical quality in an EIS include the depth and breadth of baseline studies, and the scope and detail of testable impact predictions and proposed monitoring programs. These parameters were therefore quantified for all 170 tourism EISs throughout Australia from 1979-1993 inclusive (Warnken and Buckley 1995b). These ranged from a three-meter jetty extension in NSW to a 10,000-person residential resort in Queensland. Most were coastal, though fourteen were in mountain areas. Mean area was over 200 hectares.

For the biological environment, baseline data were collected most frequently for terrestrial flora and least frequently for marine biota. Only 65% of EISs specified sampling dates for flora, 14% specified sampling sites, and 6% sampled for more than one season. For terrestrial fauna the proportions were 78, 16, and 14%; and for marine biota 78, 57, and 13% respectively. For EISs providing baseline biological data only, only 16% estimated species richness or abundance for plants, 44% for fauna, and 52% for marine biota (Warnken and Buckley 1995b).

Even fewer EISs contained baseline data on the physical environment. Water quality parameters, principally pH and temperature and less often nitrogen and phosphate, were the most frequently sampled. Groundwater was never sampled more than once, terrestrial surface waters 5.7 times on average, and marine waters 14.7 times. These last were mostly in the state of Western Australia (WA).

Most impact specifications were vague and unquantified, even for recent EISs. Some EISs differentiated between construction impacts and operations, especially in Queensland and especially for marine biota and marine water quality. Most referred at least to habitat loss, except in the State of Victoria. Mathematical models were used to predict water quality and hydrology in some EISs, especially in Victoria; but never to predict biological impacts. Groundwater predictions were more precise in the states of South Australia and WA. The degree of quantification increased from 1975 to 1987 but remained constant from 1988 to 1992 (Warnken and Buckley 1995b).

Monitoring, Feedback, and Follow-up

Monitoring was conducted for seventeen of the seventy-six tourism developments where construction work was carried out (Warnken and Buckley 1995b) Monitoring programs were often not implemented fully, and for three of the seventeen were informal. Monitoring was most detailed for the four major Queensland projects within or adjacent to the Great Barrier Reef Marine Park. Most monitored water quality; none monitored terrestrial flora or fauna, and only the four reef projects and one New South Wales ski resort monitored aquatic biota. Monitoring designs were rarely adequate to detect changes relative to baseline. In almost 50% of cases, spatial layouts were altered partway through the program. Power analyses were conducted for only three developments, all in or near the GBRMP, and power was low. In one case power was based on arbitrarily defined limits of acceptable change which did not take account of seasonal variations.

There were only seventeen individual impact predictions which were testable using monitoring data (Warnken and Buckley 1995b). Seven of these proved accurate. For six, actual impacts were less severe than predicted; and for four, they were more severe. Inadequate engineering design and inaccurate nutrient-flux models were the most common causes of inaccuracy.

Conclusions and Recommendations

By objective measures, the quality of EIA for Australian tourism developments over the past two decades has not been high. Triggering mechanisms have been circumvented, baseline studies sketchy and inadequate as a basis for testing impacts, and testable impact predictions rare; even though actual development patterns show that high quality EIA is not a barrier to successful tourism development.

Clearly, therefore, EIA assessment agencies and development planning authorities need to set significantly higher standards in demanding and assessing EIA for tourism development applications, if EIA is to play a useful role in controlling the cumulative impacts of tourism development so the industry does not degrade its own natural resource base.

The first step required in improving the technical quality of EISs in tourism, as in other sectors, is far greater attention to sampling design and power analysis in conducting baseline studies and establishing monitoring programs. This recommendation has been made many times previously. The results summarized above simply quantify some of the consequences when it is ignored.

In addition, the broad approach to EIA which has evolved for large-scale developments in other sectors, particularly those with concentrated waste streams, is not always efficient for small and medium-scale developments in the tourism sector without concentrated waste streams. A more focused scoping process is needed, taking into account the results from EIA and monitoring of similar previous developments, to identify the potential impacts which will be most critical for the development decision and channel EIA effort into baseline studies, impact predictions, and monitoring for those parameters only.

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Improving Environmental Decision-Making into the 21st Century: The Army National Guard's Environmental Compliance Assessment System Marches Onward

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Abstract

Environmental auditing is a proven, successful management tool designed primarily to assist firms and agencies in sustaining compliance with federal, state, and local environmental regulations. The Army National Guard-Environmental Compliance Assessment System (ARNG-ECAS) is just such a tool. It is one of the most comprehensive environmental auditing programs within the Department of Defense (DoD). The purpose of the ARNG-ECAS is to provide a systematic, iterative approach to identify non-compliant conditions; develop corrective actions; identify the resource requirements; and track the implementation of corrective strategies. The proactive process prompts the execution of corrective measures prior to any agency audits which can significantly mitigate environmental liability and potential as a party in enforcement actions.

Key Words: A-106 Reporting System, Army National Guard, assessment applications software, environmental auditing, Environmental Compliance Assessment System, environmental compliance auditing, environmental programs management, environmental systems management, external assessments, internal assessments, National Guard Bureau, operational research systems analysis, pollution prevention initiatives, root cause analysis, The Environmental Assessment Management Guide, Windows Compliance and Sustainment Software, ARNG, NGB, TEAM Guide, WINCASS.

Environmental Auditing: A Look at the Literature

Environmental auditing is not a new concept. Since the middle 1970s, a basic auditing methodology has been used by various organizations as a systematic verification process to help them maintain compliance with environmental regulations and corporate environmental procedures (Blakeslee and Grabowski 1985; Cahill 1987; Murphy and Stern 1982; Vincoli 1993; Wong, Roig, and Eduljee 1989). Over the next two decades, environmental auditing was refined and expanded as federal, state, and local regulatory requirements multiplied.

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As organizations with slightly different missions began focusing their environmental audits, often establishing new terminology to make their tool more mission unique, confusion has resulted within the profession. Though new names for the environmental audit emerged over time, such as an environmental compliance audit, environmental liability audit, risk assessment audit, property transfer audit, environmental site assessment, waste disposal site audit, or consent audits (Vincoli 1993), one issue that remains important in all of these environmental audits is how to ensure that compliance with regulations and corporate rules is prioritized by managers. In addition, it is important to understand that, no matter what the specific focus of an environmental audit, the methodology will remain basically the same (Greeno, Hedstrom, and DiBerto et al. 1995; Truitt et al. 1983).

Regulatory compliance is an important goal of the environmental audit. During the 1980s and into the next decade, however, the environmental audit began to evolve into more than a compliance tool as managers realized the auditing process could assist them with a variety of organizational concerns. In an extensive literature review published by Scott (1995), the author organizes uses of the environmental audit into four major functional areas (see Table 1). By observing the Major Functional Categories, in the left hand column, and each corresponding list of Specific Functions in the right hand column, one can see that the environmental auditing profession now uses the audit for much more than just regulatory compliance. The environmental audit has become a comprehensive management tool to improve a variety of internal and external issues important to the organization.

There is much agreement in the literature that the environmental audit can serve a variety of different functions within an organization. The literature also provides insight into some minor disagreements, such as: (1) external and internal auditing, (2) technically trained versus non-technically trained auditors, and (3) confidential versus open reporting of the audit results (Scott 1995). Of the three major discussions in the literature, the confidential versus open reporting argument is the most contentious.

Literature supporting confidentiality, most of which comes from the United States, suggests that public relations and financial costs due to potential legal action are too great to allow sensitive information to be open to the public (Wong, Roig, and Eduljee 1989). In the early days of the environmental auditing profession, several authors addressed legal questions by recommending ways to hide information via the attorney-client privilege (Eizenstat and Litan 1984; Truitt et al. 1983; Hall and Case 1987; Myers and McCaffery 1984). On the other hand, as the environmental audit evolved, practitioners began to question the ethical considerations of using the attorney-client privilege to hide information (Vincoli 1993), and disclosure laws began to change (DeMeester 1988). In addition, companies began to realize that open interaction with the community served to enhance the companies' public relations (Strelow 1992; Schmidheiny 1992).

The previous paragraph not only shows disagreement in the literature, but more importantly, one can see the evolution of the environmental audit as a management tool. The ARNG-ECAS is a program that experienced evolutionary change as well. As program managers, assessors, site personnel, and others associated with the program saw opportunity for improvement, the program changed to accommodate user needs. Importantly, the general methodology has remained a systematic process of observation to primarily assist field and site managers to better understand their program areas.

Table 1. Functions of an Environmental Audit

Major Functional Categories	Specific Functions
Management	• Information System • Education and Training • Evidence of Organization Responsibility • Planning • Identify Organizational Strengths and Weaknesses
Economics	• Cost Savings • Opportunity Assessments
Public Relations	• Public Relations
Legal	• Verify Regulatory Compliance • Liability • Risk Avoidance • Insurability

A Brief ECAS History

In the early and middle 1980s, evaluating environmental management practices became more important as increasing levels of environmental regulation required corporations and private industry to operate within the law or risk large monetary fines and imprisonment. To assist American business and government agencies, the U.S. Environmental Protection Agency (EPA) introduced, in 1986, an environmental auditing policy statement that touted the fundamental benefits of establishing an auditing program and provided basic methodology with recommendations for carrying out an internal organizational check of environmental management practices and regulatory compliance. In this policy, the EPA defines an environmental audit as a "systematic, documented, periodic and objective review by a regulated entity of facility operations and practices related to meeting environmental requirements" (1986).

In 1989, the Secretary of Defense, Richard Cheney, took a strong stand to improve environmental compliance and protection and make the DoD the agency leader in the federal government (U.S. DoD Report 1991). Subsequently, the DoD increased its support of environmental auditing as a proactive management tool to be used by each of the military services. For example, the U.S. Army Construction Engineering Research Laboratories (USACERL) were contracted by the Department of the Army (DA) to assist with the development of environmental compliance protocols for its installations. The resulting eighteen compliance-based protocols were written in non-legal jargon with a checklist style format, incorporated into an environmental auditing manual, and designed to assist Army program managers to better understand the multitude of environmental regulations they must comply with on a daily basis.

The Army-wide Environmental Compliance Assessment System (ECAS) evolved to become one of the agency's premier management tools. The future of ECAS within DA was bolstered by the issuance of a November 1992 Information Memorandum by then Chief of Staff of the Army, General Gordon R. Sullivan, who named the ECAS the Army's environmental auditing tool. With full support at the highest levels of the U.S. Army, major commands embraced the use of ECAS at all installations.

The Army's commitment to ECAS continues today with the recent revision of AR 200-1, the Army's regulation requiring the implementation of the program at its installations. The Army has joined in a DoD effort to standardize the environmental auditing process by jointly developing a standards manual applicable to all military services. Again, the USACERL through a contracted effort has created a joint services environmental auditing manual similar to the original DA version. "The Environmental Assessment Management (TEAM) Guide" encompasses twenty media-based protocols in a coded checklist format.

The ARNG-ECAS Program

The National Guard Bureau's Environmental Programs Directorate (NGB-ILE-E) recently completed the first four-year cycle of external assessments under the ARNG-ECAS program with the assistance of contracted consultants and its nationwide network of Installation staff. From October 1991 through September 1994, fifty-four final reports were produced, establishing an environmental baseline of compliance findings and corrective actions at over 5,000 ARNG facilities including the fifty states, the District of Columbia, Puerto Rico, the Virgin Islands, and Guam. Of significant importance, "these projects were completed on time and within budget and, in the process, have increased the environmental competence of thousands of ARNG soldiers and employees" (Cassio and Fairbanks 1995).

The success resulted largely from effective program management at all levels utilizing Total Quality Management principles. The environmental baseline documented high quality compliance data through consistent application of analytical and quality assurance/quality control (QA/QC) processes. This data provided headquarters staff with key information to maintain upper management support; and, ultimately, it helped to establish credibility for the program with site managers.

Consequently, the ARNG community began using ECAS as a corporate management tool early in the program's implementation. Adopting the standards and approach used in the external assessments, the ARNG of each state, or installation, conducted a parallel program of self audits (internal assessments) at the midpoint of the external assessment cycle. This continuum of review has enhanced organizational environmental program management.

The operations, activities, and management of the installations are appraised to verify environmental compliance with federal, state, and regional/local statutory requirements along with military regulations and acceptable standards. Originally during the first cycle, the environmental auditing manual consisted of seventeen compliance-based protocols (e.g., Clean Water Act, Endangered Species Act, etc.). An eighteenth protocol, Pollution Prevention, was added in 1994 with the passage of Executive Order 12853 to render the standards more comprehensive.

The NGB-ILE-E is presently in the first year of its second four-year assessment cycle. This is a propitious time to discuss the changing direction of the ARNG-ECAS program as it meets the changing agenda for environmental assessments in today's arena. As an example, the environmental standards and compliance categories of the TEAM Guide have been adopted to facilitate data comparison of ARNG installations against other DoD components (Table 2).

Table 2: ARNG-ECAS Compliance Categories

Air Emissions Management	Pesticide Management
Cultural Resources Management	Petroleum, Oil, and Lubricants Management
Hazardous Materials Management	Solid Waste Management
Hazardous Waste Management	Storage Tank Management
Natural Resources Management	Polychlorinated Biphenyl Management
Environmental Impacts	Asbestos Management
Environmental Noise	Radon Management
Installation Restoration Program	Lead-based Paint Management
Pollution Prevention	Wastewater Management
Program Management	Water Quality Management

Developments in the Tools

Assessment Software: TEAMCAS to WINCASS

The most evident element of ARNG-ECAS showing change as the program transitioned from the first cycle to the second cycle is the software. This was a necessary change to incorporate the media-based standards newly formatted in the DoD-adopted TEAM Guide. Even more so, this was a natural evolution to reflect the changing goals and objectives from establishing an environmental baseline (i.e., assessment and compliance verification) to assessment and compliance sustainment (i.e., review of in-place, underlying programs, procedures, and management systems).

Currently, the ARNG-ECAS uses the proprietary software The Environmental Assessment Management Compliance Assessment Software (TEAMCAS). It contains findings data referenced against the TEAM Guide and the ARNG Supplement. The latter manual inventories the organizational standards and requirements of the ARNG.

An improved version, the Windows Compliance and Sustainment Software (WINCASS) 2001, was developed to provide greater analytical and reporting capabilities including historical profiles, trends analysis, risk management analysis, project cost estimating, statistical correlation, and interfacing to proponent reporting systems within DA and DoD.

Historical Profiles

Maintaining accurate historical compliance profiles is an important aspect of any environmental compliance assessment program. The identification of carryover and repeat findings from previous assessments assists the program manager to understand the nature of the deficiency through its tracking and monitoring. These data are retrievable through the WINCASS 2001 by a downloading procedure. Various analytical steps can be performed to display trends and risk management of the findings which are essential to mitigate the impact of the deficiency.

Trends Analysis

The frequency, location, time, and other parameters of finding occurrence yield valuable insight into the nature of the deficiency and the appropriate corrective action. This analytical step begins with standardized layouts of the collected data for interpretation by the manager. The organized spread of the data is a mechanical function of the WINCASS 2001.

Risk Management Analysis

The identification and correction of fundamental causes (root causes) of deficiencies is the critical feature of any compliance assessment program. The proper application of root cause analysis, corrective action strategies, and prioritization of the strategy allows the environmental manager the opportunity to optimize resource use. This is significant in these times of corporate downsizing and limited funding.

Several analytical steps are included in the overall risk management of a finding:

1. Identification of the deficiency
2. Determination of the significance
3. Identification of the cause(s)
4. Identification of the trends
5. Determination of the corrective action
   a. Incorporation of exemplary facility practices and program performance into the organizational management planning
   b. Incorporation of pollution prevention initiatives into the strategy development
   c. Review of cost-effectiveness
6. Prioritization of implementation targets.

The functionality of tagging non-compliant conditions with root cause codes is a feature of WINCASS 2001 which is applied during the QA/QC processing of preliminary data on site. Following the validation of the preliminary data set, each finding can be tagged with a root cause code for subsequent filtering and analysis. These functions facilitate a standardized and mechanical means to review the data set as a whole or by specific segments to reveal the inherent nature of the deficiency.

Project Cost Estimating

The identification of cost-effective corrective actions and strategies is becoming increasingly important in times of reduced funding assistance. Project cost estimating associated with corrective actions developed for ARNG-ECAS-identified deficiencies are consistently streamlined through the use of the cost-estimating module of the WINCASS 2001.

Corrective projects, services, or plans necessary to resolve environmental deficiencies have been captured in an electronic library over the past five years of execution of the ARNG-ECAS program. These corrective actions are linked to a detailed catalog of pre-priced services, material, labor, and other relevant cost data to provide refined cost estimates. This project cost-estimating module follows a job-order-contracting format and will be fielded in the second quarter of 1997. Local and regional variations of the inventoried projects and services will be adjusted through application of a cost indexing factor.

Statistical Correlation

The application of the current data set and historical records poses an invaluable tool for projecting compliance activities, programmatic requirements, and forcasting resources and expenditures. The graphical analyses of these data utilize an operational research systems analysis approach. Environmental managers will have a better assessment of their program performance and, more importantly, they will be able to convey their programmatic and budgetary needs in a consistent manner to upper level decision makers. This analytical module is expected to be incorporated into WINCASS 2001 in the third quarter of FY97.

Report Interfacing

The advantages of one-time data entry into a relational database include labor and time savings, accuracy and consistency, and facilitated updating of records. The migratory functionality of the compliance assessment data has been designed into the WINCASS 2001 to interface with the DoD's A-106 Reporting System for resource requirements. Other interfacing with existing reporting systems is currently being tested and should be functional by the second quarter of FY97.

Nationwide Training

The latest initiative to streamline ARNG-ECAS focuses on a nationwide training program and eventual use of the ARNG infrastructure to perform the full range of environmental compliance services at any given time. This is an expansion of the intra-ARNG approach that pairs experienced environmental professionals with novices in the the auditing field to increase the pool of qualified individuals. This training methodology has proven successful in the performance of internal assessments.

ARNG training has provided environmental staff in each state with the capability to provide technical expertise of the military institution as well as state, regional, and local regulatory areas. This localized expertise is critical for sustaining regulatory compliance. Current year training courses are elevating the level of expertise within the ARNG ranks.

To ensure effective staffing for each assessment effort, an integrated team of skilled professionals is selected from ARNG military, civilian, and contractor staff. Experienced individuals from three contractors provide supplemental assistance, which is readily available through an existing NGB-ILE-E national contract. This corps of technical specialists possesses extensive ARNG-ECAS experience to provide not only a standardized, high quality service at reasonable costs through fixed-price delivery orders but also sound, on-the-job training to site managers and employees during the walkthrough.

National contracted services support has been significantly better than regional contracted services offered by other government agencies, as the services are not subject to district office variations. The client does not pay for training and indoctrination of first-time contractors procured from a regional listing of generically, pre-qualified firms which are unfamiliar with the institutional process. An initial testing of the enhanced ARNG-ECAS using contracted services is scheduled for February 1997 with the State of Florida Army National Guard. Subsequent testing of this approach will be conducted at targeted Installations beginning in FY97 following successful completion and reanalysis of the Fort A.P. Hill effort.

Future Applications

One important aspect of the ARNG-ECAS program is its universal adaptability to measure organizational performance whether in the public or private sector. The process and software have been authorized for use by contractors providing assessment services for the Air National Guard, the U.S. Department of Justice, the U.S. Secret Service, the Federal Law Enforcement Training Centers in Glenco, Georgia, and Artesia, New York, and an IBM manufacturing facility. Applicable state, regional/local, and corporate requirements were incorporated into the assessment applications software for the specific organization. Notable program capabilities include:

- Unique scope of services as ARNG is the only DoD component to develop a “cradle to grave” approach to resolve deficiencies with identification, analyses, and monitoring to be incorporated into a national database
- Long-term benefits of keeping environmental staff current with changing technology and legislation
- Refinements in FY97 will provide enhanced analytical options (e.g., project cost estimating, etc.).

Except for the additional software refinements scheduled for completion in FY97, the ARNG-ECAS is available for project evaluation today. Upon testing and fielding of the enhanced WINCASS 2001, the ARNG-ECAS will become an applicable corporate tool available to a global market where organizational operations and systems management can be analyzed to verify environmental compliance—and more—at every level.

This service will be possible on a site specific or a comprehensive organizational basis in accordance with the customer's needs.

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Training Approaches in Environmental Technology Assessment (EnTA)

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Abstract

Current technology assessment studies focus increasingly on the environmental impact of technologies. This is linked with a shift from technology-induced investigations to a more problem-induced approach. In contrast to this development, there seem to exist only a few systematic national or international training programs qualifying various target groups of developing and transition-economy countries for utilizing environmental technology assessment (EnTA) in decision-making processes. The International Environmental Technology Centre of the United Nations Environmental Program (UNEP), through a pilot program approach, field-tested first steps toward regional training in EnTA awareness and capacity building. Two EnTA concepts (traditional and modern), as well as various EnTA approaches (explorative, reactive, proactive, and constructive), determined the methodological discussions in this program.

Key Words: environmental technology assessment (EnTA), awareness creation, capacity building, post-graduate training, training needs, developing countries, transition-economy countries, EnTA concepts, EnTA approaches

Training Approaches in Environmental Technology Assessment (EnTA)

Industrialized countries increasingly acknowledge technology assessment (the investigation of social, economic, and ecological opportunities and risks linked with the application of new technologies) as a tool to support sustainable economic and social development. This technology-induced investigation is likely to shift to a more problem-induced approach which focuses on the environmental impact of technologies over time. A database, built up and maintained by the Karlsruhe Institute for Technology Assessment and Applied Systems Analysis (ITAS), demonstrates that out of the 406 currently covered entities throughout Europe dealing with technology assessment, 213 examine environmental impact in the course of their technology assessment activities (Coenen and Rader 1995).

At the International Environmental Technology Centre (IETC) of the United Nations Environment Program, environmental technology assessment is considered an important tool for decision makers involved in the adoption and application of a technology.

An environmental technology assessment alerts decision makers as to the appropriateness of a particular technology not only economically but socially and environmentally prior to its introduction and use. By definition, it includes several studies that systematically examine potential environmental, human health and safety effects when a technology is introduced, extended, or modified—and pays particular attention to those consequences that are usually unintended, indirect, or delayed (Meganck 1996).

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Contrasting with the increasing importance of technology and its transfer for the well-being of people and nations (including developing countries and countries with economies in transition), governments, the private sector, and academia have done little to build individual and institutional capacities for utilizing environmental technology assessment as instrument in decision-making processes to implement Environmentally Sound Technologies (ESTs). In addition to teaching (imparting knowledge), many researchers and practitioners recommend training (conveying know-how) as the most appropriate means to close this gap, particularly in developing and transition-economy countries (Brock 1995; Sucre 1993; United Nations Industrial Development Organization (UNIDO) 1995; U.S. Environmental Training Institute (USETI) 1995).

Training Needs Identification

Technology assessment practitioners, representatives of international organizations, and trainers of environmental education/training institutions argue that there is need for training in commissioning and utilizing environmental technology assessment. Some of them already have expressed more specific needs for this type of training.

Coates (1995) emphasizes the need to make decision makers more aware of, sensitive to, and able to act on potentially adverse effects of new technology, i.e., technology which may be truly new or which may only be new to the country or location into which it is proposed to be introduced and whose impacts are not fully understood. The International Association for Technology Assessment and Forecasting Institutions (IATAFI) adds training to a list of measures to link countries which lack environmental technology assessment techniques and utilization of know-how and capabilities in this field (IATAFI 1994). The EnTA Program of the United Nations Environment Program, initiated by the UNEP Industry and Environment Centre in 1993, indicates the need for capacity building in both commissioning and applying environmental technology assessment (Skinner 1994).

To enable more specific analysis of training needs among users of environmental technology assessment in developing and transition countries, the UNEP International Environmental Technology Centre (IETC) in 1995 mailed 1,500 simple questionnaires to individuals and institutions involved in performing and using technology assessment or organizing training in this field. Some 520 completed replies (35%) were received, providing insight into the training necessary to optimize the role of environmental technology assessment in the environmental management decision-making process. As an overall need, training in the ability to read technical assessment reports and other resources critically, and to recognize comparative value and capability when evaluating alternative technologies, were emphasized by respondents to the IETC questionnaire (UNEP IETC 1995).

Existing Programs Related to EnTA Training

TA users and practitioners concerned with identifying prospective substantive areas and target groups for training in this field are at the same time also the potential organizers of this type of training. A few of those organizations and institutions have already designed and implemented training events related to (environmental) technology assessment.

Possibly the closest initiative to training in EnTA is the Environmental Impact Assessment of the South Pacific Regional Environment Program, which includes twenty-two Pacific Islands together with Australia, New Zealand, France, and the U.S. (Onorio and Morgan 1995).

The Science and Technology Management Group, Free University of Brussels, together with the Flemish Institute for Technological Research (VITO), belong perhaps to the most experienced European providers of training in technology assessment. Among their TA related training events are courses on (1) methodological and organizational aspects of technology assessment, (2) TA methodology in the Ph. D training of engineers, (3) in-house training on TA methodology and R&D (Research and Development) management at research and development institutions, and (4) integrating TA in R&D management for R&D program directors and project managers (Berloznik 1995).

Representatives of the UNCTAD Division for Science and Technology consider the integration of trainees in the environmental technology assessment community as important as the EnTA training itself. This kind of networking should complement training activities along the lines of the IAIA and IATAFI (see UNEP IETC 1995). Another interesting approach to employ mass-media in capacity building and awareness creation on TA under environmental aspects has been made by five German radio stations. They transmitted a "Funkkolleg Technik" (Radio College of Technology)—a series of twenty broadcasts on various aspects of technology assessment, including such topics as TA—a political assignment, TA in companies of the private sector, TA and public participation, TA and ethical/social responsibility for citizens and environment (Funkkolleg 1995).

A Pilot EnTA Training Proposal

Based on its training needs analysis and on existing programs, UNEP IETC developed a pilot training program on EnTA for decision makers in developing and transition-economy countries. The program design was critically discussed by an expert group and through peer reviews. The revised program was then field-tested during a pilot workshop in Kuala Lumpur, Malaysia, from November 12-17,1995 (Strohmann 1996). Main objectives of the training, following suggestions of Van Langenhove and Berloznik, were (1) awareness creation on EnTA and (2) capacity building to perform and to utilize EnTA (Van Langenhove and Berloznik 1994). The program focused on an audience along the European Union lines defined by Loveridge, namely institutional and functional target groups concerned with commissioning and utilizing EnTA (Loveridge 1994). Another target group taken into consideration was the large group of project managers (European Parliamentary Technology Assessment 1995).

IETC's EnTA training program has been designed and formatted as a series of proactive workshops including on-site visits that addressed the following key topics: (1) EnTA and development issues, (2) the local case study, (3) the practice of EnTA, (4) identifying impacts of technological innovation, (5) public participation in the EnTA process, (6) technology assessment and communication (group exercise), and (7) design of national EnTA training programs. In the "practice of EnTA" session, IETC program developers focus on societal aspects of environmental technology assessment by emphasizing that EnTA studies and supports the interaction between developments in science and technology, society, and the decision-making process related with these developments.

EnTA Methods Emphasized

For methodological discussions of the EnTA process, IETC course designers introduced the characteristics of two main (environmental) technology assessment concepts, the traditional and the modern concept. A dominating role of science; the high expectations in EnTA results (usually presented as report), the problem definition as task for scientists; involvement of only one TA institution; the instrumental use of TA information; and the consideration of EnTA results in the decision-making process were identified as main characteristics of the traditional TA concept. It is opposed by more modern methods where the equal role for science and scientists; limited expectations in EnTA results which are manifested in research and discussions rather than in reports; the problem definition as result of discussion; the utilization of multiform TA capacities; the conceptual use of TA information; and the TA influence on policy rather than on decision making were stated as characteristics.

These two concepts reflect the wide panorama of TA activities/methods with different objectives and approaches and different socio-economic contexts involving different interest groups. Based on the various functions of TA (strengthening actor positions in policy making, support short- and mid-term policy, early warning, enlarge knowledge base, develop societal desirable technologies, promote acceptance of technologies, promote societal responsibility of scientists), this pilot EnTA training program discussed different ways of performing technology assessment under environmental aspects. Four EnTA "schools" (methods) were discussed: the explorative, the reactive, the proactive, and the constructive. Criteria for comparison of each method were the objective, the tools used, and the theory of knowledge (epistemology). Participants in the program and resource persons agreed that the *explorative* EnTA method has the objective to describe technological changes, uses mostly quantitative tools, and its epistemology claims that the future is known if technology is known. The objective of the *reactive* EnTA method is the analysis of environmental impacts of technologies deploying analytical tools such as expert opinions. The reactive EnTA school is positive toward the possibility to know environmental consequences of technology. The *proactive* method has the objective to introduce societal elements in the analysis of technologies through dialogue and debate (scenario workshops, consensus conferences). Its epistemology says that technology can be controlled if organized as a learning process. Lastly, the *constructive* technology assessment method introduced in the IETC pilot workshop aims at the analysis of social dynamics of technologies. This method utilizes interventions (deliberation, negotiation) as tools and stakeholders themselves construct technology.

In the EnTA practice, methods are applied in institutional categories such as academic TA, corporate TA, parliamentary TA, support to the executive branch, or research and development integrated TA. The integrated TA was strongly supported by workshop participants since it aims at steering research in order to introduce societal aspects during the R&D process. As such there is a clear engagement as an early warning instrument. The knowledge obtained as a result of this EnTA method is fed back into the process to minimize or avoid negative consequences of technology for the environment and the society (UNEP IETC 1996).

This method was also applied in a regional follow-up training program on EnTA for Sub-Saharan Africa. Scientists of the Senegalese African Regional Centre for Technology and of the Potchefstroom University for Christian Higher Education (South Africa) suggest to integrate EnTA processes in the environmental impact assessment of projects where new technologies will be adopted (Nel 1996; Asiedu 1996).

Finally, a number of conclusions and recommendations from organizers, trainers and participants of IETC training activities in the field of EnTA will be offered here for consideration in similar programs at the regional, sub-regional, national, or local level.

Training of Trainers

Before each regional or national training, a training of trainers course should be organized to ensure that regional and local resource persons fully understand the objectives of EnTA training, and to avoid discordance of views between trainers. Provision should be made particularly for promising EnTA trainers from developing countries to attend courses of distinguished EnTA teachers abroad. This initiative may lead to a series of guest lectures across developing/transition countries in Africa, Asia, Latin America, Eastern and Central Europe. While it is recognized that such initiatives are expensive, a pilot exercise for a limited number of people can be attempted.

Generating Local EnTA Training Events

The generation of local EnTA training initiatives should be supported in consultation and with the wide participation of local actors. This support needs not be financial, but it should concern itself with the definition of course content and design, as well as the provision of expertise in areas of local weakness. Local hosts of EnTA training should be chosen not only for their capabilities in providing technical facilities but also according to their ability to prepare and present an appropriate case study. This implies that, within the host country, a minimum of institutional environmental policy capacity exists.

Deciding on Trainees

Separate training events should be organized for environmental technology assessment providers and users. For both occasions, trainees have to be chosen according to their professional background in environmental decision making and their level of knowledge regarding EnTA.

EnTA As Complementary Activity

The single most critical issue regarding contents of EnTA training programs seems to be the clear distinction between environmental technology assessment and environmental impact assessment in general. Coenen and Rader (1995) mention that EnTA studies might also include trade-offs between economic and ecological impacts in the analysis. This is a significant difference distinguishing EnTA from EIA, which is a compulsory procedure legally described in many countries prior to commencing development projects. Another difference is that EnTA is conducted before the commercialization of a new technology, that is, during its development, and that the results of EnTA are intended to enable the consideration of potential ecological impacts during development and the ecological optimization of new technologies from the outset (Coenen and Rader 1995).

At the threshold of a new century, when environmental-induced investigations on technologies are of increasing demand, more structured training in this field is obviously needed for both TA providers and consumers. Developing and implementing qualified training programs for industrialized countries, as well as for those with developing or transition economies, will ensure utilization of environmental technology assessment as a useful complementary tool in making environmental-conscious medium- and long-term decisions and policies.

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Ecological Risk Assessment: A Guideline Comparison and Review

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Abstract

This paper provides a general review of five of the most recent risk assessment guidelines currently used in the United States and Europe to conduct environmental risk assessment. Though these guidelines are very general, an aggregation of common techniques and resources provides an expanded database from which a successful understanding of current risk analysis methods may be obtained.

Key Words: ecological risk assessment, U.S. Army, guidelines, European risk assessment, methods comparison

Background

Risk assessment is generally defined as the assignment of a frequency (probability) of the potential consequences of undesirable events. It is a combination of safety or hazard, reliability, and risk analyses (Henley and Kumamoto 1992). Risk analysis has long been used as an analytical method instrumental in decision making. Some of its strongest roots lie in the nuclear engineering field and in the scientific fields of toxicology and epidemiology. More specific fields of risk assessment that are generating a lot of publicity in Congress at present are human health and ecological, or environmental, risk assessment. These two fields together embody the risks of interest for most environmental issues and questions.

While most current regulations and proposed legislation require human health risk assessment in the evaluation of the probability of adverse health effects to the human population, increasing emphasis is now being placed on ecological risk assessments as well. In the case of human health risk assessment, recent methods for calculation have assessed the probabilities for developing cancerous and non-cancerous effects, or so-called endpoints. Federal regulations stipulate that the threshold endpoint is an increase in cancer risk of 10^{-6} to a human subject. Once this threshold is calculated as the expected increase in risk for some chemical, regulations kick in to take action concerning potential exposure to the chemical. Unfortunately, ecological risk does not have these convenient numerical thresholds available to indicate when a dangerous situation is imminent. Such thresholds vary with species and with the intended purpose of the assessment.

Ecological risk assessment is the evaluation of the probability and resulting adverse effects on the non-human population or the ecological system in a particular region or area from an environmental hazard or stressor (non-endemic events or chemicals which, when introduced to an environment or ecological system, have the potential to accumu-

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late, biomagnify, and genetically mutate species, poison, or in any other way impact a species or ecological system). More specifically, the assessment must evaluate the risks and determine the acceptability of those risks. *Ecological risk assessment* is a term often used interchangeably with *environmental risk assessment*.

Ecological risk assessment is used to determine the extent of potential adverse effects which result from stresses introduced to the environment from anthropologic intervention. Risk assessments may be used as a measure when the risk from an event or events could result in an unacceptable amount of damage to ecological endpoints (target species or organisms). The data that result from ecological risk assessments can be used to determine the extent of damage from a stressor or to determine the possible effects to a system or species as a result of a stressor. This information is particularly useful when determining the severity of damage or effects, when exact data are not available, or when the best or worst case must be determined from among many possibilities.

Because each situation is unique (e.g., each ecological species has unique habitats or needs, each contaminant has unique characteristics and toxicological effects, or each site has unique types of environmental components), it is difficult to address assessment techniques in any uniform or standard manner. As a result, there are many guidelines available for the purposes of evaluation of risk for different contaminants or stressors. Details presented in these guidelines range from the very general, which give only basic principles for assessment, to the very specific, which address only a certain type of environment and contaminant combination. The purpose of this paper is to present a general summary of five recent ecological risk assessment guidelines, or methods. In particular, this work will highlight a method used by the U.S. Army and four other current guidelines. The five guidelines have been reviewed to provide a comparison of methods. These guidelines included the U.S. Army Ecological Risk Assessment Guideline (ERDEC-TR-221), the U.S. Environmental Protection Agency (EPA) Framework for Ecological Risk Assessment (EPA/630/R-92/001), the European Risk Assessment of Existing Substances-Technical Guidance Document (XI/919/94-EN), the Approach and Strategy for Performing Ecological Risk Assessment for the Department of Energy Oak Ridge Field Office Environmental Restoration Program (ES/ER/TM-33), and the U.S. EPA's Risk Assessment Guidance for Superfund (EPA/540/1-89/002, vols. 1 and 2). This represents an aggregation of the most pertinent and current methods for ecological risk assessors.

Comparison of Guidelines

The following is a comparison of the individual guidelines. Two of the five guidelines include human health risk assessment (the European and the U.S. EPA's Superfund guideline). The human risk assessment sections in these two guidelines are addressed on occasion in this paper whenever such discussion serves to highlight the special difficulties in ecological risk assessment when compared to the more common and prevalent human health risk assessment experience. In general, however, a more comprehensive comparison of human health risk assessment guidelines is beyond the scope of this paper. The objective of this section is to give a general overview of current ideals and methods. To aid in identification, each guideline will be referred to as a certain number methodology.

Guideline I: the *U.S. EPA's Risk Assessment Guidance for Superfund* (EPA/540/1-89/002, vols. 1 and 2) (U.S. EPA 1985)

Guideline II: the *U.S. EPA Framework for Ecological Risk Assessment* (EPA/630/R-92/001) (U.S. EPA 1992)

Guideline III: the *Procedural Guidelines for Ecological Risk Assessment at U.S.*

Army Sites (ERDEC-TR-221, vols. 1 and 2) (Wentsel 1994)

Guideline IV: the *European Risk Assessment of Existing Substances - Technical Guidance Document* (XI/919/94-EN) (European Commission 1993)

Guideline V: the *Approach and Strategy for Performing Ecological Risk Assessment for the Department of Energy Oak Ridge Field Office Environmental Restoration Program* (ES/ER/TM-33) (Suter et al. 1992)

In the subsequent discussion, each guideline is compared by general content; regulatory drivers; software, database, or models; uncertainty analysis; risk characterization techniques; endpoint analysis; and dose analysis. The following is a general description for the points of comparison.

General Content

This particular section presents a general overview to the order of presentation of the succeeding comparison data. It outlines any specific details not included in the other areas of comparison to try to introduce some of the unique features of each guideline. The most apparent aspect in the review of these guidelines is the amount of detail or generalization with which they present the material. Hence, the guidelines are compared from the most broad to the most specific based on structure and reason for composition.

The second volume of the Guideline I is the most general ecological risk assessment (ERA) guideline reviewed. Though some areas of concern for site analysis are addressed, there are no actual methods given. The reader is referred to the Superfund Exposure Assessment Manual (U.S. EPA 1985) for more details. Guideline II is the next most general presentation of ERA methodologies; its basic structure comes from a paradigm established by the National Academy of Science. Most other ERA documents are based on the general structure of this guideline. The standard principles and definitions of this field are presented in this guideline. Guideline III, adopted by the U.S. Army, is based specifically on the structure of Guideline II but is considerably strengthened by adopting a three-tiered structure. In this Army Guideline, progressive tiers further expand the detail of data collection and analysis for better decision resolution. Guideline IV is also based on the U.S. EPA's (Guideline II) basic risk structure. However, it expands the ideas and presents a standardized method for calculations, including details on standard pathways (routes that a chemical can take from deposition to interception by a target species), releases of the chemical or stressors, and target species. Its methods are based on European regulations. Finally, Guideline V is the most specific of all the ERA guidelines. Again, it is based on the U.S. EPA's structure. However, this method is more exact to fit the needs of the Department of Energy (DOE). Specifically, it provides established endpoints (the target species and level of damage). A second document is entitled "Incorporation of Ecological Risk Assessment into Remedial Investigation/Feasibility Work Plans" (Suter et al. 1992) which employs the principles of the previously mentioned DOE guideline specifically to Oak Ridge National Laboratory Sites. The lack of standardization and definite explanation among ERA guidelines is a function of the site specific nature of this field.

The human health risk assessment portion of Guideline I presents an excellent, standardized method for human health risk and dose assessment. Effects for cancer and non-cancer sources are addressed. It also includes dose calculations for radiological hazards. The human health portion of Guideline IV also presents a very comprehensive, standardized method for risk and dose analysis in humans from chemical exposures. Risk for cancer and non-cancer effects are treated in the same fashion. However, radiological hazards are not addressed.

Regulatory Drivers

There is a wide variety of regulations which motivate the initialization and conduct of ecological risk assessment. These regulations sometimes only dictate that an environmental assessment be conducted: implying, of course, an ecological risk assessment. Human health risk assessment is usually mandated by law. The regulations presented here represent the driving forces behind the composition of these guidelines. The list is not inclusive of all regulations; only the applicable regulations are listed. Any further information regarding requirements or laws is beyond the scope of this review.

There are numerous regulations which require an assessment of the environment. The five guidelines reviewed in this paper are written and governed by these specific regulations. The regulations in this section are not inclusive of all regulations requiring risk analysis.

Many ERA guidelines are developed specifically for the Comprehensive Environmental Response, Compensation, and Liability Act/ Superfund Amendment and Re-authorization Act. Guidelines I, II, and III are written specifically for CERCLA. However, Guideline I also mentions the Resource Conservation and Recovery Act; the Clean Air Act; the Clean Water Act; the Federal Migratory Bird Treaty Act; the Endangered Species Act; the Toxic Substances Control Act; the Federal Insecticide, Fungicide, and Rodenticide Act; the Fish and Wildlife Conservation Act; the Marine Protection Research and Sanctuaries Act; the Coastal Zone Management Act; the Wild and Scenic Rivers Act; the Fish and Wildlife Coordination Act; and the Marine Mammal Protection Act. Guideline IV is written for the regulations governing existing substances, Regulation (EEC) No. 793/93 and Regulation (EEC) No. 1488/94. Guideline II is very broad and does not list specific regulatory drivers.

Software, Models, and Databases

Risk assessments techniques are highly dependent on models and algorithms for calculations. The term *software* refers to computer programs which may be used to calculate desired parameters for an assessment. The software may include models or the entire program may be referred to as a model. The term *model* refers to the use of mathematical techniques to calculate specific functions or events. The term *database* refers to a collection of empirical data (e.g., environmental or dose data) which is used as input and decision levels for models. This review presents a general review of the methods which provides the most inclusive and comprehensive list of models.

Due to incomplete site specific data, it is necessary to rely on model estimates and databases. Most of the guidelines reference techniques or actual software used for models and available databases. Guideline III, used by the U.S. Army, provides the most comprehensive list of models, databases, toxicity tests, and case studies in the second volume of its set. Guideline I lists databases and models throughout the text of the first volume. The second volume does not go into such detail. Guideline IV lists several American and European databases and models available to the assessor. Most techniques and models are based on the U.S. EPA's methods. Guidelines II and V do not list any specific software; however, they reference several sources.

Uncertainty Analysis

Uncertainty as used in this comparison is defined as:

> Imperfect knowledge concerning the present or future state of the system under consideration; a component of risk resulting from imperfect knowledge of the degree of hazard or of its spatial and temporal pattern of expression (Suter 1993).

The issue of uncertainty calculation is germane to the effectiveness of a risk assessment. This review lists the guidelines which address this issue and the extent to which it is addressed. Further information regarding actual techniques is left for the reader to obtain from the individual guidelines.

Four of the guidelines address uncertainty. With the exception of one, the guidelines reference other sources for methods of uncertainty determination and measurement. The common generators of uncertainty include formulation of the conceptual risk model, incomplete information and data, natural variability in parameters of the risk model, and procedural design error. The exception to this is Guideline I (volume I), which employs a system of uncertainty factors and modifying factors (UFs and MFs, respectively). These are quotient factors of tens. Based on levels of uncertainty in data, the dose is divided by the UFs and MFs to reduce the dose to a more conservative value. This simple approach gives a good baseline for uncertainty calculations.

Risk Characterization

The term *risk* as used in this comparison of guidelines is defined as:

> the probability of a prescribed undesired effect. If the level of effect is treated as an integer variable, risk is the product of the probability and frequency of effect...Risks result from the existence of hazard and uncertainty about its expression (Suter 1993).

The determination of risk is the one of the ultimate goals for risk assessment. This review addresses the extent and ranks the effectiveness of risk tabulation for each guideline. Further information regarding actual techniques is left for the reader to obtain from the individual guidelines.

The four U.S.-based ecological risk assessment guidelines (all except the European Guideline IV) employ two basic principles for risk calculations: the hazard quotients and probable strategies. The hazard quotient uses a series of hazard indexes and doses based on reference or benchmark dose to the target species. The proximity of the benchmark dose determines the hazard. This approach is highly dependent on professional judgment and is very subjective. The probability of development of adverse effects (e.g., reproductive reduction or genetic effects) or mortality is a typical risk quantity of interest. The European method (Guideline IV) is similar to the latter; the actual risk is calculated with the guidance of EEC Regulation 1488/94. Guideline I (volume 1) addresses risk calculation the most thoroughly. The first volume in Guideline I also calculates two types of risks to humans: one from cancer using a probability and one from non-cancer hazards using a hazard quotient. Guideline V has a unique system of calculation; risk is not calculated in a probabilistic manner, but rather in a quantitative manner (not employing hazard quotients). The damage to a specific land or species is measured against criteria to determine the acceptability of damage.

Three of the U.S.-based methods (Guidelines I, II, and III) employ Hill's criteria for causal associations. Guideline IV did not address causation. Guideline V uses an adaptation of Koch's postulates.

Endpoint Analysis

An endpoint is defined as the target species or system which is subject to an environmental hazard. This review addresses the extent and ranks the effectiveness of endpoint determination for each guideline. Further information regarding actual techniques is left for the reader to obtain from the individual guidelines.

Three of the methods (Guidelines I, II, and III) use the U.S. EPA's (Guideline II) ideals of measurement endpoints (the species or population for which the predetermined damage is assessed) and assessment endpoints (this is the final or tertiary damage to a species which, if found to occur, represents an unacceptable amount of impact on an ecological system or environmental process). The definitions of these are found in Guideline II. These guidance documents also include case studies and examples to further define and aid in selection of these endpoints. Guideline IV presents five populations which are the designated to be protected: aquatic ecosystems, terrestrial ecosystems, top predators, micro-organisms in sewage treatment systems, and the atmosphere. The endpoints for Guideline V are used typically for DOE-contaminated sites and are assessed over three levels: discrete operable units of the proposed restoration technology, the watershed, and the entire restoration facility. The specific measurement endpoints are chosen as plants, threatened and endangered species, and sensitive local animal populations. The assessment endpoints are listed as:

- damage to any threatened or endangered species
- a 20% or greater reduction in abundance or production of a select local
- community of plant or animal
- any damage to wetlands or floodplains

In contrast to the vast array of endpoints possible in ecological risk assessments, human health risk assessment is based on a single species analysis—death to humans. Guideline I (volume I) is based on a summation of cancer probabilities and hazard quotients to all human populations. Guideline IV is structured on standard pathway exposures, namely: acute toxicity, irritation, corrosivity, sensitization, repeated dose toxicity, mutagenicity, carcinogenicity, and toxicity for reproduction. The targeted human population includes: workers, consumers, and indirect exposure from the environment.

Dose Analysis

The term *dose* is a "...a gauge of integral exposure; how much contaminant is uptaken by an endpoint species" (Suter 1993). The methods or endpoints methods for each guideline are compared in this review. The determination of dose is very complicated and is beyond the scope of this report. However, this report does present some very basic concepts to aid an informed reviewer with the general techniques used by each guideline. This enables the reviewer to categorize the extent and possible techniques by which each guideline manages dose calculation. From this information the reader may potentially be able to apply these various techniques to meet specific assessment needs. Further information regarding actual techniques is left for the reader to obtain from the individual guidelines.

Ecological risk assessment is based on epidemiological (laboratory and wildlife) data. Doses for the species or communities are determined though a series of reference doses. These doses are deliberated by specific measurements which cause observable adverse effects. Some of these measurements include LD_{50} (lowest dose that will cause a 50% mortality in exposed population or species), LOAEL (Lowest-Observable-Adverse-Effects-Level, the lowest dose that will produce a statistically or biologically significant change in adverse effects in an exposed population), NOAEL (No-Observable-Adverse-Effects-Level, the dose at which no statistically or biologically significant change in adverse effects are produced in an exposed population), and NOEL (No-Observed-Effects-Level, the dose at which no effects are produced in an exposed population or species). These reference doses are associated with all of the reviewed guidelines. Guideline I (volume II) states that the use of NOELs is impractical because the observed effects are required to assess critical damage. Guideline IV uses a formula to calculate the NOELs based on conservative assumptions. Synergistic effects are discussed by both Guideline II and IV. Also common to all methods is the use of QSARs (Quantitative Structure-Activity Relationship), estimation techniques used to predict effects or properties of chemicals based on the structure of the substate to estimate doses when no toxicity data are available. Guideline V utilizes a potential benchmark and presents a discussion on the reliability of each method used to evaluate damage from the doses. These methods include NWQC (one-half the dose that would cause 50% mortality in 5% of exposed populations), concentrations causing a set percentage reduction in the most sensitive response parameter, concentrations causing a set percentage reduction in production for a chronic toxicity test, and concentrations that result in a set percentage reduction in a field population.

Again, as a means of contrasting with human health risk, both human health risk assessment guidelines (I and IV) utilize the reference dose method (e.g., LD_{50}, LOAEL, NOAEL, etc.). The methods for dose calculation are determined mostly by models because of the lack of available human data. Guideline I utilizes reference doses (Rfd) for non-cancerous effects observed at certain levels. The doses from cancerous sources are considered non-threshold. Guideline IV is based on the proximity of the estimated dose from exposure to the dose for measured effects for both cancer and non-cancer effects.

Summary and Recommendations

This methods review presents a general overview and summary of five of the most recent and prevalent ecological risk assessment guidelines. Each guideline is reviewed for general content, purpose, or objective; regulatory drivers; software, database, or models; uncertainty analysis; risk characterization techniques; endpoint analysis; and dose analysis. Based on this comparison of current methodology and resources for risk analysis, the data may be assimilated to aid in construction and execution of an efficient risk assessment paradigm. The extent of need for specific details, references, or methodology is highly dependent on the depth of the analysis. Some of the guidelines are very specific in methods for calculation and estimation; the Army guideline is particularly sophisticated in this regard.

The use of general algorithms and techniques for sites requiring exact or site specific details has the potential to introduce a great deal of error. However, the use of specific but non-applicable methods to a site has just as much potential to introduce a great deal of error. Furthermore, use of detailed analysis could be an unnecessary waste of time and resources when the desired answer does not require the extent of singularity or the data are insufficient to support the need of the techniques. It is the recommendation of this methods review that, in order to establish a stable foundation for an effective risk assessment, it is necessary to first examine the most general guidelines for content of methods. The more specific guidelines may then be employed for reference and example techniques, given that the needs of the analysis and the extent of the data support such effort.

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Risk Communication in Environmental Assessment

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Abstract

Since the enactment of National Environmental Policy Act (NEPA) and other environmental legislation, the concept of "risk communication" has expanded from simply providing citizens with scientific information about risk to exploring ways of making risk information genuinely meaningful to the public and facilitating public involvement in the very processes whereby risk is analyzed and managed. Contemporary risk communication efforts attempt to find more effective ways of conveying increasingly complex risk information and to develop more democratic and proactive approaches to community involvement, in particular to ensuring the participation of diverse populations in risk decisions. Although considerable progress has been made in a relatively short time, risk communication researchers and practitioners currently face a number of challenges in a time of high expectations, low trust, and low budgets.

Key Words: risk communication, risk perception, public involvement, public participation, message development, framing, trust

Introduction

Perhaps not surprisingly, since its subject is communication, the literature on risk communication has grown enormously since the passage of NEPA in 1969. The 1978 Council on Environmental Quality (CEQ) regulations for implementing NEPA (40 C.F.R. Parts 1500-1508), helped to define the two major aspects of contemporary risk communication: (1) message development, or conveying technical and specialized information in a way that is comprehensible and usable for lay people, and (2) public participation in decisions involving, or potentially involving, risk. Communication in the basic sense of message development is touched on in 40 C.F.R. 1502.8, which states that "Environmental impact statements shall be written in plain language and may use appropriate graphics so that decision makers and the public can readily understand them." In addition to the various specific requirements for public input, such as public scoping for environmental impact statements, 40 C.F.R. 1506.6 more generally requires agencies to "make diligent efforts to involve the public in preparing and implementing their NEPA procedures."

Subsequent legislation and recent historical events and trends have further contributed to the growing significance of risk communication efforts in environmental assessment. U.S. Environmental Protection Agency (EPA) policy in relation to the Superfund Amendments and Reauthorization Act of 1986, for example, requires that a community relations effort accompany any Superfund remedial investigation and response. The American Indian Religious Freedom Act (1978), along with other legislation protecting Native American rights, and Executive Order 12898 (1994) on environ-

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mental justice add requirements for including cultural and demographic considerations in environmental decision making, with important implications for risk communication. Highly publicized disasters such as the reactor accidents at Three Mile Island (1979) and Chernobyl (1986) and the toxic gas leak at Bhopal, India (1984), served to increase public concerns and demands to be fully informed about risks. Concurrently, there has been a decline in public trust in government and industry, a fact which presents risk communication with one of its greatest challenges, since trust is essential to successful communication.

Risk Perception Theory and Message Development

At its most basic level, risk communication is an effort to convey scientific or technical information about risks to a non-scientific, non-technical audience. Early practitioners discovered, however, that the task was more complicated than translating scientific into lay language. Fundamental to the evolution of risk communication as a unique discipline was the theory developed by Paul Slovic, Baruch Fischhoff, and others that “the concept ‘risk’ means different things to different people” (Slovic 1986, 1987). Building on earlier work by Starr (1969), Slovic uses psychometric techniques to produce quantitative representations or “cognitive maps” of lay people’s attitudes toward and perceptions of various activities and technologies (e.g., how risky they are, how much regulation is desirable). The research shows that, while technical experts tend to equate riskiness with estimated fatalities, lay people often judge riskiness, and therefore the acceptability of risk, by other characteristics: “In particular, perception of risk is greater for hazards whose adverse effects are uncontrollable, dread, catastrophic, fatal rather than injurious, not offset by compensating benefits, and delayed in time so the risks are borne by future generations” (Slovic 1986). Similar characteristics are designated by Sandman as components of “outrage”—i.e., those aspects of hazards which are not directly related to their scientifically demonstrated harmfulness but which people care about (Sandman 1989).

Risk perception research holds many important implications for message development. Morgan, Fischhoff, and their colleagues have written extensively on the “mental models” approach (Morgan et al. 1992; Atman et al. 1994; Bostrom et al. 1994), which is based on the premise that “people process new information within the context of their existing beliefs” (Morgan et al. 1992). Therefore, risk communicators need to ascertain the current state of recipients’ knowledge and beliefs (for example, through open-ended interviews and other means), in order to design messages that will provide information that is both useful and usable.

Other research reveals that not only individual psychological and cognitive patterns but also cultural factors and values have a significant influence on risk perception. In “The Social Amplification of Risk: A Conceptual Framework,” Kasperson et al. point out that “messages have meaning for the receiver only within a sociocultural context” (Kasperson et al. 1988), an idea that has taken on increased importance with the emphasis on analyzing the impact of environmental decisions on diverse ethnic and cultural groups. For example, in “The Significance of Socioeconomic and Ethnic Diversity for the Risk Communication Process,” Vaughan notes the accumulating empirical evidence that “risk behaviors and attitudes evolve within, and are framed in reference to, broader sociocultural variables” (1995).

Contemporary Issues and Methodologies (Message Development)

Two major, comprehensive works on risk appeared in 1996: the draft report on *Risk Assessment and Risk Management in Regulatory Decision Making*, issued by the Commission on Risk Assessment and Risk Management (Commission 1996), and the National Research Council's *Understanding Risk: Informing Decisions in a Democratic Society* (NRC 1996). Responding to public and Congressional concerns (e.g., Bill HR2910, the "risk communication" bill, introduced in 1993), both studies stress that risk information must be usable by all affected parties and must be "transparent," that is, "revealing and characterizing the assumptions, uncertainties, default factors, and methods used to estimate risks" (Commission 1996). Three key issues for message development emerge from a review of these recent works, but all have been raised earlier as well.

Risk Comparisons

The use of comparisons in risk communication involves something of a paradox. Comparisons are a well-established device for conveying unfamiliar information; on the other hand, as shown in an influential work by Covello, Sandman, and Slovic (1988), using comparisons to explain risk can often be counterproductive. In particular, the authors warn against comparing unlike risks or risks with different "outrage" quotients (for example, living near a contaminated waste site versus driving a car), a tactic which can appear trivializing or irrelevant to affected parties. Although other practitioners have questioned some of the earlier authors' acceptability rankings (for example, see Lundgren 1994), their general guidance remains standard in the literature. The Risk Commission's draft report concludes that risk comparisons can be helpful, but should be used cautiously, avoiding comparisons of unlike risks (Commission 1996). Again, however, a potential challenge emerges, for, as scientists become able to detect ever smaller amounts of suspected carcinogens, finding sufficiently similar risks for a meaningful and acceptable comparison becomes increasingly difficult, and the discussions may be so subtle as to elude the non-scientific reader.

Uncertainty

Uncertainty in risk communication essentially refers to the acknowledgment that quantitative measurements of risk are frequently imprecise, although the commonly used point estimates seem to suggest otherwise. Two possible correctives recommended in current literature are to express risk estimates as a range, rather than a single number, and to supplement quantitative information with qualitative information. The Risk Commission report suggests including "a careful description of the nature of the potential health effects of concern, who might experience the effects under different exposure conditions, the strength and consistency of the evidence that supports an agency's classification of a chemical or other exposure as a health hazard, and any means to prevent or reverse the effects of exposure," in addition to "the range of informed views about a risk and its nature, likelihood, and strength of the supporting evidence" (Commission 1996). Again, the recommendations imply some challenges for risk communication. If not presented with care, the qualitative information mentioned above, while probably more accessible to lay readers, may also be overwhelming in its sheer volume. A research project by Johnson, and Slovic (1995) suggests that presenting a range of estimates rather than a point estimate may have mixed results in terms of reader comprehension and attitudes toward the agency providing the information (for example, it may be variously interpreted as honesty or as incompetence). Nevertheless, the authors conclude that uncertainty, which is inherent in risk assessment, must be part of accurate communication about risk, although considerable research is needed on the best ways of presenting uncertainty to the public.

Framing and Embedded Values

"Framing" or "framing effects" refer to the way information is presented, the "slant" given to data. For example, mortality rates associated with two therapies might be presented in terms of number of deaths or number of survivors, and the presentation will influence the recipients' choice of treatment (Slovic 1986). Although framing effects can be a useful tool in responsible risk communication—for example, Vaughan says that agency officials communicating with minority communities need to use language and information related to the frames adopted by the community (Vaughan 1995)—Slovic argues that the effectiveness of subtle differences in the way risks are presented "raises ethical problems that must be addressed by any responsible risk-information program" (Slovic 1986). The inherently subjective nature of "factual" information is also acknowledged in *Understanding Risk*: "Measuring each type of outcome presents its particular set of judgments, and each judgment embeds values" (NRC 1996). Nothing can change the fact that even scientific and quantitative communication is not neutral; however, acknowledging this truth and ensuring that various perspectives are made available can help to offset intentional or unintentional framing effects. "So long as decision participants understand which value assumptions underlie an analysis, the analysis can serve the decision." However, when the value assumptions are opaque (e.g., hidden in unnecessarily complex mathematical techniques or models), the analysis begins to take over the decision, and suspicion and distrust result (NRC 1996).

"Two-Way Communication" and the Growth of Public Involvement

At the conclusion of "Perception of Risk," Slovic provides one version of a recurrent theme in risk communication literature:

> Lay people sometimes lack certain information about hazards. However, their basic conceptualization of risk is much richer than that of the experts and reflects legitimate concerns that are typically omitted from expert risk assessments. As a result, risk communication and risk management efforts are destined to fail unless they are structured as a two-way process. Each side, expert and public, has something valid to contribute. Each side must respect the insights and intelligence of the other (1987).

The idea that risk communication is a two-way activity is not new. It is implicit in the public participation requirements in environmental legislation and in the repeated discovery that one-way communication, however well designed, is inadequate from both a practical and a philosophical perspective. Covello and Allen (1992) emphasize that "A basic tenet of risk communication in a democracy is that people and communities have a right to participate in decisions that affect their lives, their property, and the things they value." The literature of the past ten years is filled with exhortations to involve the public early and often and with suggestions for how citizens' participation can be more meaningfully effected (Covello, Sandman, and Slovic 1988; Covello, McCallum, and Pavlova 1989; Chess in Covello, McCallum, and Pavlova 1989; U.S. EPA 1992; Lundgren 1994).

Contemporary Issues and Methodologies (Public Involvement)

In a 1994 survey reported in the proceedings of a national symposium on "Addressing Agencies' Risk Communication Needs," leaders in the field identified the two issues of highest priority as (1) integrating outside (i.e., non-agency) publics and concerns in agency decision making, and (2) communicating with diverse ethnic and socioeconomic groups (Chess et al. 1995).

Current approaches to involving a variety of publics essentially build upon the concept of two-way communication, expanded to accommodate a growing sensitivity to issues of distributive and procedural justice and increasing public distrust of conventional, regulation-driven approaches. For example, the Office of Solid Waste and Emergency Response Directive #9230.0-20 on "Innovative Methods to Increase Public Involvement in Superfund Community Relations" acknowledges that citizen participants question whether they actually influence the U.S. EPA's decisions and suggests exploring such options as citizen work groups and workshops, the use of bilingual communication, and open houses/availability sessions (U.S. EPA 1992). In its *Summary Report to the President: The Presidential Regulatory Reform Initiative*, the EPA describes more recent efforts to forge "grassroots partnerships" with stakeholders. Some examples include the "Partners in Protection Initiative," begun in 1994, in which tribal, minority, and low-income communities at various sites identify agency project activities, and the "Brownfields Economic Redevelopment Initiative," in which affected communities are brought into the decision-making process for the cleanup of contaminated urban land (U.S. EPA 1995).

"Science in a Fishbowl: Public Involvement in the Hanford Environmental Dose Reconstruction Project" describes a project initiated by another government agency, the Department of Energy (DOE), to deal with the issue of public distrust—in this case, a perceived conflict of interest if DOE were to control a study of its own site. The project, which lasted from 1987 to 1994, established an independent Technical Steering Panel (TSP) of technical specialists and public, state, and Native American representatives to direct the study. Innovative features included unqualified access to TSP meetings; to the laboratory and staff working on the project; and to all documents and communications, whatever their status or stage of development (Shipler 1995).

Increasingly, citizens require not just consultation but empowerment as part of the two-way risk communication relationship. Dillon points out that "community involvement" activities which consist of providing information, issuing documents for review, and using citizen advisory groups as sounding boards can do little to avoid controversy because citizens still feel excluded from the actual decision-making process (Dillon 1995). The question of empowerment or control is particularly important in overcoming what Kasperson calls the "participation paradox," in which those most affected by a risk may often be the most uninvolved in the decision making and the most difficult to reach (Kasperson 1986).

Executive Order 12898 (1994) re-enforces the need for innovative approaches to involving traditionally unempowered communities and communicating risk in a way that is meaningful for such communities. Vaughan notes that, in predominantly minority or lower-income communities, environmental risks are increasingly being framed as questions of distributive justice (fairness in the allocation of resources and costs) and/or procedural justice (fairness in the decision-making process). "Democratic participation in deciding about an environmental risk situation is being framed as a right of all communities, and communication processes perceived as being exclusive can lead to distrust, opposition to risk management decisions and a loss of credibility for the government agency or industry involved" (Vaughan 1995).

Understanding Risk advocates "experimental efforts to provide resources to allow meaningful participation for parties that could not otherwise join effectively in deliberations" (NRC 1996), adding that such efforts should focus on risk decisions that seriously affect the parties in question and should be designed and evaluated in collaboration with those parties. Carpenter describes one example of community empowerment, in which members of the Mohawk Native Americans at the Akwesasne near the St. Lawrence

River initiated and served as local investigators in a study of suspected chemical contamination of fish, a major component of the community's diet. Carpenter attributes the success of the project in large part to the fact that the risk communication "messengers" shared the ethnicity and background of the affected community, with outside sources providing further technical expertise and grant money for the field staff (Carpenter 1995). Another, NEPA-related example is the *Environmental Impact Statement for the Nevada Test Site [NTS] and Off-site Locations in the State of Nevada,* for which the Department of Energy invited representatives of the Consolidated Group of Tribes and Organizations (CGTO), representing seventeen tribes and organizations with ancestral ties to the NTS, to write sections of the EIS and an appendix presenting their concerns and views on the alternatives and the technical analyses. The DOE/NTS adopted the CGTO's recommendation that they compensate the writers for their services and travel expenses, and provide the writers' group with funding, technical assistance, and resources (DOE 1996).

Other approaches to public involvement discussed in recent literature include the "social learning" procedure described by Webler, Kostenholz, and Renn in the siting of a municipal waste disposal facility in Switzerland. Distancing themselves from the potentially divisive focus on empowerment and subjective satisfaction, the authors call their example, with its emphasis on cognitive enhancement and moral development, an attempt to foster a more community-based, problem-solving approach to environmental questions (Webler, Kostenholz, and Renn 1995). Appendix B of the NRC report describes a multi-attribute utility analysis in which participants were asked to list and prioritize their criteria for evaluating decision options related to the siting of a coal-fired power plant in Florida. These criteria were subsequently weighted, discussed, and revised in a series of iterative steps which helped to clarify the decision process (NRC 1996). McClendon's "Trust Perception: Using Cognitive Maps to Discover Stakeholder Perspectives" is interesting because it focuses directly on a frequently-cited obstacle to effective risk communication. Extrapolating from Kasperson's idea of the social amplification of risk, McClendon calls trust perception "the social amplification of trust." Cognitive mapping of trust, using association-driven issue display (AID), enables stakeholders themselves to define the elements of trust, thereby clarifying their own attitudes and potentially increasing the chances for consensus (McClendon 1996).

What all these approaches have in common, and what is relatively new about them, is that they encourage affected parties to acknowledge and elucidate subjective views and values (either personal or local), rather than to ignore them. Although the techniques are sometimes cumbersome, they can enhance communication by helping participants better understand their own and others' concerns and wishes.

Challenges, Recommendations, Next Steps

Risk communication literature is full of recommendations for effective practice, and most of them are good. Yet, despite some very real advances in agency attitudes and risk communication techniques, writers repeatedly cite the gap between theory and practice. The proceedings from "A Symposium to Discuss Next Steps" express concern over continuing institutional reluctance to employ risk communication and suggest that research should be directed toward agencies themselves and how to overcome institutional barriers to meaningful public participation in decisions (Chess et al. 1995).

Institutional hesitancy may in part be motivated by—but also contributes to—the fact that risk communication today remains something of an experimental field. As recently as 1996, the draft report on *Risk Assessment and Risk Management in Regulatory*

Decision Making can say that "We know very little about how to ensure effective risk communication that gains the confidence of stakeholders, incorporates their views and knowledge, and influences favorably the acceptability of risk assessments and risk-management decisions" (Commission 1996). Similarly, the National Research Council, advocating an "analytic-deliberative process" for risk decisions, notes that "there is little systematic knowledge about what works in public participation, deliberation, and the coordination of deliberation and analysis" (NRC 1996).

One reason for the continued sense of uncertainty about "what works" in risk communication is the ever evolving concept of risk itself, which, as Gadomska points out, is becoming "more and more extended in the social consciousness," to encompass threats to future generations, to quality of life, the culture of a community, the beauty of a landscape, and the planetary ecosystem (Gadomska 1994). Regarding agencies' responsibilities, the NRC points out that organizations rarely evaluate or report the results of their risk communication efforts (NRC 1996). This need for organizational planning and evaluation has already received attention (Chess, Allen in Covello, McCallum, and Pavlova 1989; Weinstein and Sandman 1993; Lundgren 1994; and Chess et al. 1995). The NRC report stresses organizations' need to consider such measures as training staff; acquiring analytic expertise in ecological, social, economic, or ethical outcomes; making organizational changes to facilitate internal communication and flexibility; and instituting procedures for evaluation, both during and after communication efforts (NRC 1996).

Many of the newer approaches reviewed here are promising, but some may also seem to portend daunting expenditures of time, money, and effort, as well as a potential conflict with efforts to streamline the NEPA process and reduce the size of documents. Discussing some qualities of effective risk communication, Covello et al. cite a hierarchical organization, which allows people who want answers to find them quickly while people who want details can also find them (Covello et al. 1993), an approach which might help writers manage the increasing complexity of risk documents. Shipler acknowledges that the unique level of public involvement in the Hanford dose reconstruction project contributed to its taking longer and costing more than initially planned. However, he also provides suggestions for improving similar efforts in the future, including (1) early, mutual agreement on purposes, goals, roles and responsibilities, and (2) a cooperative development of processes and procedures (Shipler 1995).

The NRC offers two responses to concerns that an extensive analytical-deliberative approach could become prohibitively complex and time-consuming. First, they emphasize that a fully implemented version of such an approach would be appropriate for only a relatively small number of risk decisions (for instance, those with a high potential for controversy), but that those cases have an importance disproportionate to their number. Secondly, given the huge costs and delays (e.g., from legal challenges) that can arise from inadequate public involvement, and given the current atmosphere of skepticism toward government and regulatory agencies, they argue that it is better to err on the side of too broad rather than too narrow participation (NRC 1996).

Effective risk communication can lead to better decisions, but, as the NRC report acknowledges, an excellent deliberative process still may not reduce the differences between the parties. Nor can a successful resolution of these differences guarantee that the results will be accepted by decision makers. However, although the authors stress the need to be aware of such limitations, and to make participants aware of the limitations, they also comment that, "Even if participation does not increase support for a decision, it may clear up misunderstandings about the nature of a controversy and the views of various participants. And it may contribute generally to building trust in the process, with benefits for dealing with similar issues in the future" (NRC 1996). In other words, agencies trying to implement broader risk communication efforts should adopt a realistic, learning-oriented attitude toward both successes and failures.

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Social Assessment

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Abstract

Social assessment is widely applied to the design and implementation of policies, projects, and programs with a strengthening institutional base in legislation and organizational structures. An iterative, issues-oriented process of social assessment is applied throughout the project-program cycle, integrating qualitative and quantitative data, and emphasizing the involvement of interested and affected parties. Key activities include scoping, projection, and estimation of effects through scenario development and monitoring and evaluation.

Key Words: social assessment, public involvement, social change, scoping, monitoring, soft systems

Introduction

Social assessment (SA) has become a strong part of the planning and implementation of projects, programs, and policies, and can be traced back to the early 1970s, as described in Finsterbusch (1980); Freudenburg (1986); Burdge (1994); Burdge and Vanclay (1995); Taylor, Bryan, and Goodrich (1995); and Bryan (1996). It is a process that uses a number of methods of social analysis, monitoring, and public involvement to plan, instigate, and manage environmental and social change.

The development and evolution of the social assessment process and methods parallels that of environmental assessment in general, and institutionally it is now established firmly in many countries, including the U.S., Canada, Australia, New Zealand, South Africa, and, increasingly, in Europe. Social assessment is also part of the procedures of project design and implementation in key international development agencies.

Although the process of social assessment and many of the methods most commonly used in the field have been relatively well defined in the last few years, procedural and methodological refinements continue and are addressed in this paper.

Strengthening of the Institutional Base for Social Assessment

The institutional basis for social assessment provides the all important context for the focus and strategy of the process. In particular, the institutional context is vital in defining the extent of public participation in the process, the relative reliance on qualitative and quantitative data, and the extent to which it is integrated with other aspects of the assessment process, such as bio-technical assessment and the initial, overall

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design of the project or policy (Taylor, Bryan, and Goodrich 1995).

The New Zealand Resource Management Act (1991) is regarded by many as the foremost and most innovative national legislation for environmental assessment in recent years. This act has included mandatory requirements for the assessment of environmental effects, with “social,” “cultural,” and “amenity values” clearly included in the definition of environment. Also required are public involvement and community consultation, and monitoring of effects once the plan or project has begun. Other countries are revising their legislation or putting legislation in place to achieve similar ends.

In addition to national legislation, there have been developments with national guidelines. Foremost is the initiative in the U.S. with publication of “Guidelines and Principles for Social Impact Assessment” prepared by The Interorganizational Committee (1994). These guidelines demonstrate a greatly increased consensus on the nature and process of social assessment. Many of the early developments in the field were made in the U.S., but in a fragmented way. For example, different approaches characterized the academic setting of universities, compared to efforts in state and federal agencies. Individual agencies, such as The U.S. Forest Service, now have refined and standardized their guidelines for the conduct of social assessment and supported them with in-service training.

International agencies such as the World Bank (1991), the Asian Development Bank (1994), and the Development Bank of Southern Africa have produced detailed procedures and manuals for social assessment. Aspects of social assessment are being incorporated into development projects at both the design and implementation phase. Very recently, there has been the move of developing SA guidelines within multinational corporations, such as in the case of Shell Oil (Jones, Fuller, and Slater 1996).

Definition of the Process

As the institutional basis for social assessment has been more firmly established, the basic process has been more clearly defined. Taylor, Bryan, and Goodrich (1995) point out that the field has struggled with poor definition of terms, but there is now an emerging consensus among practitioners about the main elements of the social assessment process and their application to the project-program cycle. The process used by the authors in assessment work and training through the early 1990s is outlined in Table 1. A very similar process was proposed by The Interorganizational Committee (1994) for the U.S.

The Process and the Project-Program Cycle

Too often the process outlined is seen as being step-by-step rather than iterative, emphasizing the need to recognize the project-program cycle. There has been wide acceptance of the concept of project-program cycle in environmental assessment, as published by the World Bank (1991), and its adaptation to accommodate the different elements of the social assessment process above (Taylor, Bryan, and Goodrich 1995).

One of the most important consequences of the emerging consensus about the project-program cycle is that social assessment is just as important in the implementation stage as itis in the preceding design stage, as shown in the simplified cycle in Table 1. The persistent image of a field focused narrowly on the “prediction” of social change has thankfully diminished, although it remains emphasized in key papers (such as Burdge and Vanclay 1995: 32) where SA is defined as “the process of estimating, in advance, the social consequences...,” despite the importance placed on monitoring, mitigation, and management by such authors.

Table 1: Outline of Social Assessment Process

Scoping	Initial public involvement and identification of issues, establish variables to be described/ measured, and links between bio-physical and social variables, and likely areas of impact and study boundaries
Profiling	Overview and analysis of current social context and historical trends
Formulation of alternatives	Examination and comparison of options for change
Projection and estimation of effects	Detailed examination of impacts of one or more options for change
Monitoring, mitigation, and management	Collection of information about actual effects, and the application of this information by the different participants in the process to mitigate negative effects, and manage change in general
Evaluation	Systematic, retrospective review of the social effects of the change being assessed including the social assessment process that was employed

The cyclical nature of the assessment process also allows us to clarify the central modes of analysis in the process. The design phase is obviously in the mode of predicting and estimating effects. The implementation stage, in contrast, is in the mode of measuring and describing actual effects. This distinction allows a subtle but important redrawing of the process, as shown in Table 2.

Soft Systems Approach

A useful distinction can also be drawn for practitioners from the application of soft systems methodologies to social assessment, as discussed by Warren et al. (1992). Soft-systems methodology is being used in a wide variety of contexts, from the analysis of major social policy reforms such as health restructuring in New Zealand to the planning of agricultural development projects in the South Pacific Islands. The central theme is to capture the essence of "wholes." It was originally developed for solving problems with complex technical systems. Extended to complex social problems, the notion of "problem" is replaced with that of "problem situation." As Warren et al. (1992) tell us, this distinction is important because "problem situations" are considered as a "collection of unstructured problems." Conversely, the definition of a structured problem implies that there is a "solution," whereas for social problems the method places emphasis on the achievement of feasible and desirable changes.

The soft-systems method, based on the early work of Checkland (1981), is systemic, dynamic and interactive, requiring iterations or feedback loops in order to be effective. As an argument for social assessment methods, the approach should be regarded as an

Table 2: Projection Techniques for Social Assessment

Trend extensions	Projection of a current trend such as population change or employment into the future
Population multipliers	Extrapolation of population size by a coefficient to account for the change in another variable such as demand for community infrastructure or services (has been extended by use of a micro-computer model; Leistritz, Coon, and Hamm 1994-5)
Consulting experts	Use of expert knowledge such as researchers, professional consultants, local authorities, or knowledgeable citizens
Historical comparisons	Examining how a particular community or social setting has responded to change in the past
Comparison communities	Comparing communities to be affected by an alternative with communities that have already undergone a similar action
Institutional analysis	Analysis of the social structure of a community—usually in terms of the number, nature, and diversity of ways for the delivery of human services vital to the survival and prosperity of the community
Economic base models	Projections of direct, indirect and induced changes in employment and expenditure by sector, using multipliers from an existing base
Willingness to pay	An indirect measure of the value of an externality (i.e., non-market impacts) to the individual

operational framework, "...rather than a cookery book recipe" (Checkland 1981: 63). The similarities between soft-systems method and the analytic-inductive approach (Taylor, Bryan, and Goodrich 1995) become very clear when they are used in practical field contexts, such as the design of an agricultural development project across several different Pacific islands, each with their own social-cultural and farming systems, natural resource base, and infrastructural difficulties. Both the soft systems methods and issuesorientated social assessment approach described by Taylor, Bryan, and Goodrich (1995) allow a shift to a more interpretive perspective, the integration of qualitative and quantitative data, and the involvement of a full range of participants and interest groups in the analytical process.

Taylor, Bryan, and Goodrich (1995) have redefined the social assessment process in the light of the soft-systems philosophy and methodology. The main component of this redefinition is the separation of “real world” activities in the process from “conceptual” or “analytical” activities. In this way the analytic-inductive approach is overlaid on the general SA process steps, tackling a difficulty that has persisted in the separation of these two key elements. The separation of the “real world” and “conceptual” is in itself arbitrary. They are in all practicality linked continuously in the iterations that can be expected to take place in the course of any assessment work.

The Importance of Scoping

As Sadler (1996: 113) finds for EA in general, that “scoping is the foundation for effective EIA [sic],” scoping is also generally recognized as the crucial first step in any social assessment. As indicated in the process components in Table 1, scoping is a preliminary investigation to identify issues and focus the social assessment. During scoping it is necessary to select key variables for social analysis, and to make an initial description of likely areas of impact. Most important to a participatory approach, scoping usually involves the initiation of a consultative process, involving open and honest communication with interested and affected parties. In an issues-oriented approach, this consultation is crucial to the identification of important issues relating to a proposed action; and for determining and planning the timing, depth, and extent of the analysis needed, and the extent to which both secondary and primary data will be available or needed.

Recent practice also confirms the importance of scoping for linking bio-physical effects with social outcomes. Where the social assessment is part of an environmental assessment, it is undertaken from the basic proposition that all actions affecting the environment have social effects to varying degrees. Analysis to establish these linkages is an enterprise requiring cooperative and interdisciplinary effort. The assumption is not valid that somehow environmental effects and social effects are unrelated, or that the respective analyses should be done separately without reference to each other. Thus, the development of a procedure for establishing these linkages in the assessment process is a key step.

A specific technique to link bio-physical and social variables in a “web” of cause and effects relationships is a webbing and chaining exercise developed for the U.S. Forest Service. The procedure is much more of an analytical exercise than “tick the box” matrices of project and impacted population variables sometimes used by assessment teams. As with the matrix exercise, however, it can be essentially a “brainstorming” process, with all key members of the interdisciplinary analysis team in attendance. Each of the issues (i.e., anticipated effects) in the scoping workshop is visually depicted, and connected where possible with lines and arrows of assumed cause-and-effect relationships. This “conceptual model” can become a working document as other interested and affected parties—whether lay people or scientists—are contacted to identify their concerns. Members of the team can offer the working cause-and-effects document to different stakeholders for their response and contributions, and a coding system can be used to delineate the major areas of concern for which more detailed analysis will be necessary.

The webbing and chaining of effects in most practical cases can soon become complex, as discussed by Taylor, Bryan, and Goodrich (1995). The scoping exercise therefore has to be analytical rather than descriptive, keeping the focus on issues rather than becoming bogged in superfluous information. The exercise must also be interdisciplinary, as different specialists consider the linkages that emerge. In so doing, they need to push the different connecting links to the social realm, to bridge the gap between biophysical and social concerns. The ongoing process of analysis process will determine if these early anticipations of effects, and the linkages between them, are valid.

The Involvement of Interested and Affected Parties

For this preliminary estimation of effects it is also important to ensure that an understanding is developed as to who the interested and affected parties are, and how they are affected (Bryan 1996; Taylor, Bryan, and Goodrich 1995). Where a proposed new road is to cross a neighborhood, for example, issues might include noise, traffic congestion and safety, property values, the road as a social barrier, improved access, newcomers and crime through improved access, or new business opportunities in servicing highway traffic. These issues could involve a wide range of interested and affected parties, from local home owners to schools, police, business operators, or public agencies. Some might be approached through groups or organizations, others may not be organized or vocal and require more indirect or subtle approaches. Usually a networking or snowballing approach is used to set the consultation in motion, informed by an understanding of the social groupings and relationships from the social profile.

The public involvement work needs to be undertaken with an understanding that different alternatives, mitigation strategies, or the management of change could result in different outcomes for different stakeholders. The objective is to maximize the positive effects and minimize the negatives, but this is a difficult or impossible task if all issues are not pushed to include their social implications for the different stakeholders.

The Projection and Estimation of Effects Through Scenario Development

The projection and estimation of effects as initiated during scoping will continue through the design phase of a project or policy. Ideally it will be based around the analysis of different alternatives, and eventually a preferred option that is to be developed in some detail. This work should also include the identification of likely needs and opportunities for the mitigation and management of impacts.

Much effort in social assessment has focused on the development and refinement of techniques for the projection of effects. It remains a basic fact for both biophysical and social assessment that it is very difficult to make accurate projections. Therefore the use of several projections techniques with an analytic-inductive methodology remains the recommended approach. To use a navigation analogy, if the navigator only has one compass on board or must rely solely on the sightings taken of stars and planets and the compass is not accurate or the weather is cloudy, projections of time and date of arrival (not to mention the destination!) become problematic. It is best to use as many different projection techniques as is reasonable, so as to be able to “triangulate” to the destination.

Social assessment practitioners have a number of basic projection techniques available to them as discussed in Taylor, Bryan, and Goodrich (1995) and Bryan (1996). Some of these may be considered “economic projection” methods, but all are capable of contributing to the development of a plausible scenario of change.

The results of analyses using these different techniques would usually be combined into an overall model or scenario of likely impacts. The scenario might be “tested” in a number of iterations involving the assessment team and interested and affected parties through the consultation activities.

Monitoring and Evaluation

As there has been much stronger recognition of the importance of the implementation phase of the project-program cycle, so much more emphasis has been placed on monitoring and evaluation in recent years. The main purpose of the monitoring of social effects is to identify any important discrepancies between expected and actual effects of an action. In this way the "scenarios" are brought in the "real world" and "feasible changes" become distinguished more clearly. At any stage in the implementation adjustments may be necessary in the change being implemented, to help reduce unanticipated and unwanted effects, or to enhance benefits. Furthermore, the monitoring can inform the management of change in the form of impact agreements, as in the case of Ontario Hydro developments at Niagara (Smith 1995), or in resettlement planning and management (Barendse and Visser 1995).

It is generally accepted that social monitoring should continue throughout the period of change, although the intensity of effort may vary. Evaluation is usually separate from, but complementary to, the monitoring and management of social impacts. Monitoring and evaluation have been most clearly defined and most effectively used in the management of projects undertaken as part of international assistance (Casley and Kumar 1987). Whereas monitoring should be linked into the ongoing management of a project, evaluation will attempt to assess the outcome of a project or program in relation to its stated goals and objectives. Here the use of the logframe analysis (New Zealand Ministry of External Relations and Trade 1993) has proven particularly useful. While at times this type of analysis can become repetitive and overly structured, it does place an emphasis on distinguishing variables that can be used to report social, economic, and environmental effects, not just to project management or the development agency, but to all interested and affected parties. A further benefit of monitoring and evaluation is the creation of information about change that can be used in the design of future projects through future comparative studies (as discussed in Burdge and Vanclay 1995) and improved scenario construction.

Conclusions

After a period of consolidation and, at times, even stagnation during the 1980s, social assessment has flourished internationally in the last five years. It has become well established in national environmental and other legislation, and is now seen as playing a key part in the assessment of effects for most projects, and increasingly for programs and policies.

Most importantly, social assessment is well placed to play a key part in ensuring that participatory methods are used in environmental assessment. Nonetheless, there is always a danger of reversion to technocratic approaches. There is much greater awareness among professionals involved in environmental assessment of the need to ensure that public involvement does not have disappointing outcomes. The public are increasingly cynical about being involved in decision making when there is little or no opportunity to influence decision making. People expect outcomes that will meet their needs, placing an onus on practitioners to "get it right."

Furthermore, by driving all issues to the social through the process of public consultation and involvement, it is possible to achieve high integration of social-economic and bio-physical assessments. As Burdge and Vanclay (1995) suggest, social assessment can be considered as "an integral part of the development process, not a step or hurdle to overcome." The participatory and issues-oriented approach concentrates on identifying "socially significant" effects rather than making arbitrary distinctions between types of effect. The analysis should be supported by other technical assessments as appropriate. The focus of the assessment work then goes onto the best outcomes for interested and affected parties, either through improved alternatives in the design phase or through mitigation and management of effects in the implementation phase.

In addition, better understanding of the project-program cycle will lead to improved management of change in social and environmental assessment. Management of change should be supported by social analysis in the form of social monitoring or evaluation. In turn, these activities are issues driven and focused by the requirements for the management of change as well as meeting the needs of all the parties involved.

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Economic and Fiscal Impact Assessment

F. Larry Leistritz[1]

Abstract

Economic impacts (changes in employment, business activity, earnings, and income) and fiscal impacts (changes in costs and revenues of governmental units) that result from projects, programs, and policies are of substantial interest to decision makers. This paper provides a brief review of methods that are commonly used in assessing these two categories of impacts. In addition, the importance of economic and fiscal impact assessment to policy making and impact management is discussed.

Key Words: economic impacts, fiscal impacts, multiplier effect, multipliers, input-output (I-O), models, export base, economic contribution studies

Economic and Fiscal Impact Assessment

The effects of resource or industrial development projects or of changes in policies and programs on the economy and population of an affected region or local area are of substantial interest to decision makers. Impact assessment specialists have categorized these effects, often termed *socioeconomic impacts*, in a number of ways; but such classifications almost always include *economic* impacts (including changes in local employment, business activity, earnings, and income) and *fiscal* impacts (changes in revenues and costs among local government jurisdictions). This paper provides a brief review of methods that are commonly used in assessing these two categories of impacts. In addition, the importance of economic and fiscal impact assessment to policy making and impact management is discussed.

Economic Impact Assessment

The purpose of an economic impact assessment is to estimate the changes in employment, income, and levels of business activity (typically measured by gross receipts or value added) that may result from a proposed project or program. As with the assessment of other categories of impacts, the general approach involves projecting the levels of economic activity that would be expected to prevail in the study area with and, alternatively, without the project. The difference between the two projections measures the impact of the project (see Webster, this volume). A related, but separate, issue is the valuation of nonmarket goods and services (see Taff and Leitch, this volume).

Export base theory (also termed "economic base theory") provides the conceptual foundation for all operational economic impact assessment models. A fundamental concept of export base theory is that an area's economy contains two general types of economic units. The *basic sector* comprises those firms that sell goods and services to

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markets outside the area. The revenue received by basic sector firms for their exports of goods and services is *basic income*. The remainder of the area's economy consists of those firms that supply goods and services to customers within the area. These firms comprise the *nonbasic sector*, also known as *residentiary* or *local trade and service* activities.

A second key concept in export base theory is that the level of basic activity in an area uniquely determines the level of nonbasic activity, and a given change in the level of basic activity will bring about a predictable change in the level of nonbasic activity. This relationship is known as the *multiplier effect*. Thus, export base theory emphasizes external demand for the products of the basic sector as the principal force determining change in an area's level of economic activity.

The basis for the multiplier effect is the interdependence (or *linkages*) of the basic and nonbasic sectors of an area's economy. As the basic sector expands, it requires more inputs (for example, labor and supplies). Some of the inputs are purchased from local firms and households. As the firms in the nonbasic sector expand their sales to the basic sector, they too must purchase more inputs, and so on. Increased wages and salaries paid to labor and management by the basic sector, together with similar payments by the nonbasic sector, lead to increases in the incomes of area households. Some of this additional income is spent locally for goods and services, some is saved, and some leaves the area as payments for imported goods and services (or as additional tax payments to the government). These flows of funds out of the local area are *leakages*. The output of local firms increases to the extent that additional income is spent locally for goods and services, and additional cycles of input purchases and expenditures result. This cycle of spending and respending within the local economy is the basis for the multiplier effect (Leistritz 1994).

The proportion of a given dollar of additional income that is spent locally determines the magnitude of the multiplier effect. High multiplier values are associated with high levels of local spending, which in turn imply a diversified, relatively self-sufficient economy. Leakages reduce the local multiplier effect. Larger regions tend to have higher multiplier values.

Assessment Methods

When estimating the magnitude of secondary economic effects (resulting from the multiplier process) for a specific project in a given area, most analysts employ either an *export base model* (employment or income multipliers) or an *input-output* (I-O) *model*. In recent years, analysts have applied input-output models with increased frequency in impact assessment. Two reasons for the increasing use of I-O models are (1) this technique provides more detailed impact estimates (e.g., business volume and employment by sector) than other approaches and can better reflect differences in expenditure patterns among projects, and (2) data bases and data management systems are now available that enable development of I-O models tailored to local conditions but based largely or totally on secondary data sources.

Commonly used I-O models of this type include IMPLAN (Alward et al. 1989), RIMS (U.S. Department of Commerce 1992), and REMI (Treyz 1993). Rickman and Schwer (1995), Crihfield and Campbell (1991), and Brucker, Hastings, and Latham (1987) provide recent evaluations of these and similar I-O models. For examples of studies that apply input-output models in the analysis of various projects and programs, see Duffy-Deno and Robison (1995), Weber (1995), Deller (1995), Borden, Fletcher, and Harris (1996), Ryan (1994), and Leistritz (1995).

Whatever modeling system is used, the analyst will need specific information about the proposed project or program in order to prepare an assessment of its economic impacts. The magnitude and timing of impacts from any project are dependent on many factors, including work force requirements (including temporary vs. permanent workers, timing of employment, earnings, and skill requirements), capital investment, local input purchase patterns, output, and resource requirements. Obtaining reliable information on these topics can be a major task and may require not only extensive consultation with project officials but also examination of experience in developing analogous projects in similar areas. On the other hand, much of the information is useful in assessing other impact dimensions as well.

Recent Developments

While researchers trace economic impact assessment back at least sixty years (to the work of Leontief 1936; Hoyt 1933; and others), it also appears to be a topic with considerable current interest. Recent emphases in economic impact analysis include (1) additional attention to estimating the spatial distribution of economic impacts and (2) greater emphasis on studies aimed at measuring the size or importance of an industry (as opposed to analyzing the implications of a specific change in the industry that might be induced by a project, program, or policy).

Analysts have addressed the geographic distribution of economic impacts through multi-regional input-output analysis, through use of geographic information systems (GIS), and by estimating community-level multipliers. Multiregional input-output models allow analysts to estimate the impacts that a particular project or program (e.g., reduced timber harvest) undertaken in one region (e.g., a rural, timber-dependent area) might have on another region (e.g., the metropolitan, regional trade and service center). Recent examples of studies of this type include analyses of the effects of reduced timber harvests in the northwestern United States (Weber 1995; Waters, Holland, and Weber 1994; Hughes and Holland 1994) and of a state policy aimed at stimulating oil and gas production (Duffy-Deno and Robison 1995).

The increasing capabilities of GIS have led to greater interest in using such systems in economic impact assessment. A recent example is a study of new town development in Hong Kong (Sui 1995) based on the integration of GIS and an extended shift-share economic model to estimate the distribution of jobs by type (blue-collar vs. white-collar), by place of work, and place of residence of the workers.

The belief that the proportion of spending and respending that generates local multiplier effects will vary with the hierarchial level of community in which an activity is located motivates the estimation of community-level multipliers. A recent study in Saskatchewan, Canada estimated multipliers for communities at six functional levels (from minimum convenience centers to primary wholesale-retail centers), which represent the trade center hierarchy in the province. The resulting multipliers were found to vary with functional level, with the smallest communities having the smallest multipliers (Olfert and Stabler 1994). Thus, the estimated local economic impacts of a given activity (e.g., a new industrial plant) would be greater if the facility were located in or near a larger city, rather than in an isolated small town, because of the higher level of leakages which characterize small towns. These community-level multipliers do not, however, provide explicit estimates of the distribution of economic impacts that occur outside the local area.

Studies aimed at determining the size or economic importance of an industry appear to be more common in recent years. For example, analysts may undertake studies of the importance of agriculture in a state or region because industry representatives desire to use this information to lobby either on budgetary or policy issues by touting the importance of agriculture to the economy (Leones, Schluter, and Goldman 1994). Increased public debate over national agricultural policy in the United States, as well as state and regional conflicts over resource and environmental issues affecting agriculture, has provided a motivation for a number of these analyses (for example, Carter and Goldman 1992; Johnson and Wade 1994; Coon, Leistritz, and Majchrowicz 1992; Bangsund and Leistritz 1995). These studies typically use input-output analysis to estimate the effect of the industry (e.g., North Dakota's agricultural sector, the U.S. sunflower industry) on other sectors of the economy. When such studies have the aim of measuring the economic importance of an industry, rather than assessing the impact of a change in the industry's output, they are sometimes termed *economic contribution* studies (Bangsund and Leistritz 1995; Coon and Leistritz 1988).

Fiscal Impact Assessment

The purpose of fiscal impact assessment is to project the costs and revenues of governmental units that are likely to occur as a result of a development, policy, or program. The governmental units of primary interest generally are those local jurisdictions that may experience substantial changes in population and/or service demands as a result of the project. The fiscal implications of a new project are determined by a number of factors, including project characteristics (e.g., the magnitude of investment, the size and scheduling of the work force) and site area characteristics (e.g., state and local tax structure, the capacity of existing service delivery systems) and by the nature of the economic and demographic effects resulting from the project. Furthermore, because the fiscal impacts of a project are of considerable interest to local officials and their constituents and to developers, the fiscal impact assessment should be designed to produce information in a form that is user-friendly to policymakers (Johnson 1988; Leistritz and Murdock 1988).

Issues Related to Fiscal Impact Assessment

Some issues that frequently concern policymakers relate to the distribution of project-related costs and revenues, both over time and among jurisdictions, and the risks to which local government may be exposed because of uncertainty regarding the future of the project and/or the nature of its impacts. The problem of cost and revenue timing, frequently referred to as "the front-end financing problem," arises because, during the early years of a project, local public sector costs frequently increase more rapidly than project-induced revenues.

While project-related revenues may exceed project-related costs over the life of the project, local jurisdictions may face short-run cash flow problems. These problems can be exacerbated if local governments are unable to obtain funds to offset revenue shortfalls through borrowing. Uncertainty associated with a proposed project also may discourage local officials from incurring financial obligations, even though borrowing might seem a logical approach to financing new infrastructure. Questions concerning (1) whether a project will actually be developed, (2) whether it may be abandoned prematurely, and (3) what the actual magnitude and distribution of project-related growth will be may make local officials reluctant to make commitments.

The interjurisdictional distribution problems may be as severe as those associated with cost and revenue timing. The project facilities that generate most of the new public sector revenues may be located in one county while most of the project-related population lives in a different school district, county, or even a different state. Fiscal impact assessments should be designed to identify these intertemporal and interjurisdictional distribution problems in advance so that decision makers can have the opportunity to devise strategies for coping with them. (For discussions of such coping strategies, see Leistritz et al. 1983 and Leistritz and Murdock 1988.)

Fiscal Impact Assessment Techniques

Specific techniques employed to estimate the fiscal impacts of projects or programs differ somewhat in the details of the estimation procedure, and assessments differ substantially in the scope of costs and revenues addressed. In general, the revenues of local governments can be broadly classified as own-source revenues (i.e., taxes and charges assessed and collected directly by the local jurisdictions) and intergovernmental transfers (i.e., funds received from state and federal levels). Own-source revenues can be further classified according to their primary determinants into those based on property valuation, those based on income or sales, those based on the level of production of some industry, and those based largely on changes in population. The techniques which are most appropriate for estimating revenues from these sources will differ depending on the revenue source (Burchell and Listokin 1978).

Intergovernmental revenues are often more difficult to project than own-source funds. These difficulties arise because the allocation formulas are frequently complicated, eligibility for certain forms of assistance changes as local wealth or other indicators change, and overall community effects often must be considered. For example, in the U.S., state school aid often is inversely related to local wealth, and so a new project that significantly affects the local tax base could affect the level of state assistance not only for the new students associated with the specific project but also for all other students in the locality. In such situations, the analyst must take account of this overall net change in order to obtain a realistic estimate of the effect of the project on the community.

A number of approaches can be employed in estimating the community service costs associated with growth. Cost estimation methods can be categorized into average cost and marginal cost approaches by the nature of the cost estimates they provide. The average cost approaches include the per capita expenditures method, the service standards method, and the use of cost functions derived from cross-section regression analysis. Marginal cost approaches include the case study approach, comparable city analysis, and economic-engineering methods (Burchell, Listokin, and Dolphin 1985; Leistritz and Murdock 1981).

Recent Developments

Fiscal impact analyses have been part of the planning profession in the U.S. since the 1930s (Mace 1961). Planners initially employed this type of analysis in evaluating public housing and urban renewal projects. During the suburbanization of the 1950s, fiscal impact analysis was employed to gauge the impact of single-family houses on local school districts. During the 1960s, fiscal impact techniques were applied to evaluate the effects of new industrial development on local governments (Hirsch 1964; Kee 1968). In the 1970s, fiscal impact analysis emerged as an almost universal accompaniment to large-scale development proposals.

In recent years, local and state governments in the United States appear to be giving greater attention to fiscal impact issues (Johnson 1988). This may be due, at least in part, to the rising fiscal pressures experienced by these governmental units since the early

1980s (Johnson et al. 1995). These pressures, in turn, are partially a result of declining levels of fiscal aid from the federal government.

One result of decreasing federal involvement in many types of domestic programs is that states have been taking more initiative in economic development activities (Leistritz and Hamm 1994). This involvement in turn leads to demands by state policymakers for analyses of the fiscal implications of state economic development initiatives (for example, see Markley and McNamara 1995; Duffy-Deno and Robison 1995).

Another observable trend in fiscal impact analysis is increasing use of microcomputers. A 1991 survey of fiscal impact models in use around the U.S. revealed that almost half (ten out of twenty-three models) were used on microcomputers (Halstead, Leistritz, and Johnson 1991). With the increasing power and availability of microcomputers, it appears likely that most new applications of fiscal impact analysis will use them. The availability of fiscal impact models designed for microcomputer use in turn suggests that local officials will increasingly have direct access to these tools (Johnson 1988).

Importance to Policy-Making and Management

Economic and fiscal impact assessments are increasingly demanded by policymakers and resource managers because they address issues that are key to a wide variety of decisions. For example, in determining whether to designate certain public lands as wilderness areas, land managers may feel a need to consider the economic and fiscal impacts of alternative land uses (e.g., wilderness vs. ranching or mining). When large-scale mining and resource development projects have been proposed, the local economic and fiscal impacts often have been one of the principal topics of debate, and special taxes and/or impact payments have sometimes been imposed to mitigate potential fiscal problems for local governments. On the other hand, the economic impacts of proposed resource and industrial development projects are often seen as among the most positive, and project proponents frequently volunteer estimates of secondary employment and income effects as part of their applications for required permits.

As state and local governments become more heavily involved in economic development efforts, economic and fiscal impact analysis tools can be useful in helping establish priorities for incentive programs. While a number of states are now using selected measures of direct economic impact (generally the number of jobs created) as criteria in awarding financial support (Leistritz and Hamm 1994), the total economic impact (including secondary effects) would appear to be a more meaningful criterion. Similarly, local governments have long been involved in providing tax abatements and other incentives to new firms. In an era of budget stringencies, local units may feel an increasing need to examine secondary as well as direct benefits and costs in determining the use of scarce resources for incentive programs. Economic and fiscal impact analysis offers tools that can be useful in guiding such decisions (Leistritz and Hamm 1994).

Recommendations

In order for economic and fiscal impact assessment to meet these growing demands, impact analysts/researchers and entities that sponsor impact studies should give concerted attention to several issues. For impact analysts, it is an often-noted (Leistritz and Murdock 1981), yet still highly applicable, conclusion that greater attention to the validation of impact assessment models and techniques is necessary. In addition, more longitudinal, *ex post*, and comparative analyses of impacts of various types of projects are essential to provide a more adequate understanding of impact processes and of the role of contextual factors in determining outcomes.

For those who sponsor impact studies, it is important to recognize that high quality economic and fiscal impact studies, like high quality analyses in other areas (Taff and Leitch, this volume), require significant resources. The availability of user-friendly, computerized assessment systems does not eliminate the need for analysts who have a thorough understanding of economic and fiscal impact assessment methods and their application. Furthermore, sponsoring agencies should recognize the need for investments in the ex post and comparative studies so necessary for improving the reliability of impact analyses.

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27

Valuation of Nonmarket Goods and Services for Environmental Assessment

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Abstract

Most environmental goods and services are not traded in a marketplace. Because of this, economists cannot directly use market-based evidence to estimate people's willingness to buy or sell these goods. Several methods to estimate market-like values have been developed, among them stated preference, revealed preference, and shadow pricing. Each approach has its own strengths and weaknesses, as does any scientific method. While applications of each are common in the literature, recent conceptual developments are mostly concerned with stated preference techniques such as the contingent valuation method.

Key Words: economic, valuation, nonmarket, contingent valuation, revealed preference

Valuation of Nonmarket Goods and Services

Environmental amenities are often affected directly or indirectly when humans make choices to enhance individual and social well-being. Societally efficient decision making requires information about all of the benefits and all of the costs of each alternative (see Leistritz, this volume). Because economic values for nonmarket goods and services are often unknown, some costs and benefits were ignored when decisions were made in the past. More recently, however, both government policies and economic science have evolved to better link nonmarket values into public decision making. Informal and intuitive valuations are no longer deemed adequate when impacts to environmental amenities are debated.

Rigorous and sound economic assessments are useful for public investment analysis, damage assessment, program planning and management, resolution of public policy conflicts, and communicating with the public. This usefulness is recognized in state and federal laws, rules, and regulations that require inclusion of the values of nonmarket goods and services in project and program assessment (Plater, Abrams, and Goldfarb 1992). For example, the Comprehensive Environmental Response, Compensation, and Liability Act of 1984 (CERCLA or "Superfund") imposes financial liability for damages to natural resources. Also, the Resource Conservation and Recovery Act of 1976 authorizes financial penalties when hazardous material disposal leads to environmental damage.

Several issues concern analysts seeking to assign economic values to nonmarket goods. We can only note them in passing for this brief review. Two general references are Freeman (1993) and Willis and Corkindale (1995). First, it is crucial that the analyst

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understand the principles and concepts of welfare economics, because many of that subdiscipline's assumptions are deeply embedded in the decision-making models that rely upon economic valuation (Laslett 1995). Second, interdisciplinary approaches are frequently required, and it is preferable to involve specialists from different subject areas early in the valuation process. Third, economic analyses are not the same as financial analyses, because they involve costs and benefits that accrue to people other than the initial decision-maker. Fourth, some economic analyses may not address changes in income distribution or losses that cannot be compensated, even though these may be important considerations in some circumstances. And, finally, the economic values estimated for use in social benefit-cost models are not at all equivalent to the "ecological values" defined in many environmental studies. This can lead to semantic confusion unless analysts and writers are clear as to which type of value is being addressed.

Economists hold that it is not the environmental asset itself that people value. Rather, people place economic value on the various services that flow from the resource's physical and biological functions. Each such service—flood damage reduction, hunting opportunities, scenic amenities, open space—has associated with it a separable economic value, the estimation of which might require a different empirical technique. Environmental assets have economic value only because they provide services that people are willing to pay for. If there is no anticipated change in human well-being, there would be no economic value associated with a change in the status of the asset.

The economic value of an environmental service is the monetized increase or decrease in human well-being brought about by changes in that service. Economic theory can show that economic value so-defined corresponds to "surplus," the extra money someone would have been willing to spend for a good but did not have to spend because the actual price was something lower. Surplus is the amount of well-being achieved by the individual over and above the amount of money (if any) that changed hands.

A critical distinction with respect to environmental services is between use and non-use values. The former are those that require some sort of direct human interaction for them to have a non-zero effect upon human well-being. These kinds of values can often be measured by looking at associated spending patterns, such as travel costs or housing purchases, or by measuring direct payment like access fees. The so-called non-use values are those increments to well-being that can be attributed to a resource even if it is never visited or used or even seen. "Just knowing it is there" is enough. Many of these "existence values" (there are other types of non-use values delineated in the literature as well, such as bequest and option values) can be measured through certain survey techniques such as contingent valuation.

Recent Conceptual Developments

Most nonmarket valuation methods fall into one of three categories, depending upon the basic approach to the problem: (1) stated preference (e.g., contingent valuation), (2) revealed preference (e.g., travel cost method and hedonic pricing), and (3) shadow pricing (e.g., replacement cost, next best alternative).

Stated Preference

Stated preference methods force respondents to state and sometimes rank their preferences for real or hypothetical proposed changes in nonmarket goods and services. Of these, the contingent valuation method (CVM) has come to be the tool of choice among many resource economists and resource management agencies. CVM's popularity lies in its ability to ascribe monetary values to goods and services that are never marketed (clean air, for example) or do not even exist (a million acres of new prairie, for example).

People are asked, through highly structured surveys, what they would pay toward the creation of a new environmental asset or what they would accept for a reduction in the services generated by such an asset. Mitchell and Carson (1989) is the most often cited primer on the techniques of CVM.

All values and prices, marketed or nonmarketed, are also contingent upon property rights, technologies, and individual preferences. So it is difficult to establish a benchmark value against which to compare the results of a valuation study. Recent experimental evidence suggests, however, that the values obtained from well-constructed contingent valuation studies are "convergent" with the results from studies that use direct approaches such as the travel-cost method (below). For example, Carson et al. (1996) looked at over 600 comparisons of CV and revealed preference (RP) valuations. They found a high degree of correlation between the two types of estimates, suggesting that CV studies are not far off the mark, as some critiques have suggested.

Revealed Preferences

Revealed preference methods indirectly estimate values by examining the pattern of consumption of associated goods and services that do have market prices. Two principal tools have become dominant in the literature: hedonic pricing and the travel cost method .

Hedonic Pricing

Hedonic pricing analysis is based on the notion that economic goods such as houses are really just aggregates of different characteristics. It is the combination of characteristics that determines what a person is willing to pay for the good. Because these characteristics are not sold separately in markets, they do not have individual prices. For example, the "right to live next to a wetland" is not commonly marketed, but it has some value to a homeowner nonetheless. This proximity factor can be thought of as an attribute of home ownership in certain locations, so we can turn to housing market sales data to infer the value. The result is, strictly speaking, the value of the right to live next to a wetland, not the value of the wetland itself. Hedonic models are used to disentangle the implicit prices of each characteristic from the single observed purchase price for the property as a whole. Palmquist (1991) provides a useful theoretical basis for hedonic price estimation.

Recent conceptual work is modest because the technique is widely held to be both valid and practical for a wide range of valuation problems. An awkward theoretical hurdle was cleared when Palmquist (1992) showed that the technique was valid in single local settings despite the absence of information about other markets. Smith and Huang (1995) note the importance of properly dealing with local economic and environmental idiosyncrasies.

Travel Cost Method

Travel cost analysis has long been employed by resource management agencies to estimate economic values. Its essence is to generate a demand curve for a resource by arraying people's expenditures against their visits to the resource. The area under the demand curve is, by definition, the economic surplus generated by the resource. Movements along or shifts in the demand curve can be used to estimate the effects of changing underlying characteristics such as water quality. Travel cost estimates have been widely used in benefit-cost studies. Good overviews are available in Braden and Kolstad (1991) and the National Research Council (1994).

Other Shadow, Surrogate, and Proxy Pricing Techniques

Other techniques are sometimes used to estimate nonmarket values. These are generally second best methods, employed when time and resources do not permit application of one of the stated or revealed preference methods discussed above. Nevertheless, their application requires no less conceptual insight or economic expertise than do the other valuation methods.

The replacement cost method supposes that an environmental service, like clean air for example, might be provided equally well either by protecting a particular prairie or by constructing a filtering machine. Because people are presumably indifferent between paying for the filter or paying the same amount to save the prairie, the economic value of the prairie (more precisely of the air cleaning services of the prairie) can be no higher than the cost of the filtering machine. This reasoning leads to a useful economic maxim: the economic value of an environmental service cannot exceed its full replacement cost. Sometimes it is easier to estimate the cost of replacement than it is to estimate the societal benefits of the environmental asset.

Expenditures made by recreationists can serve as a basis for estimating the surplus received due to activities associated with environmental amenities. Leitch and Hovde (1996) found that waterfowl hunters had a willingness to pay for their experience that was 40% greater than their out-of-pocket expenditures. They used this surplus to represent an upper bound on the contribution of wetlands to the waterfowl hunting experience. Leitch and Hovde (1996) used a residuals approach to estimate the economic contribution of wetlands to harvested wetland products. In particular, the economic value of wetland in the production of wetland hay was estimated to be the residual, that amount remaining from the market price of hay after all other inputs were compensated. This is often used to value the contribution of water to irrigated crops, for example.

Issues

The March 1992 issue of *Water Resources Research* (28[3]) contains a series of useful articles that examine the question of benefit transfer. Under what conditions is it proper to use economic values for an environmental service that were generated at a site perhaps hundreds of miles away or were generated by examining a completely different environmental asset? The question is all the more important when considering the transfer of values for nonmarket goods, the accuracy of which is sometimes called into question. Willis and Corkindale (1995) also devote a chapter to the topic.

Not all analysts are comfortable with what they consider to be a quick adoption of economic valuation results in decision making. Vatn and Bromley (1995), for example, argue that the “compaction” of information by valuation studies can in some cases lead to decisions that are inferior to those made without explicit prices. Sagoff (1994) challenges the whole notion that preferences should underlie environmental decision making in the first place. He argues that decisions which aim to satisfy preferences have “no demonstrable relation with any conception of welfare or well-being.”

Hanley (1995) suggests some preferences may be “lexicographic”; for example, an individual might always chose environmental quality over any other good, effectively placing an infinite value on environmental amenities. Although some stated preference studies seem to support this notion for some people, it is not generally consistent with observed behavior. An exception to this generality might be Greenpeace volunteers who say they are willing to risk even their lives to protect the natural environment.

Applications

The applications literature for nonmarket valuations has become enormous—witness the need/possibility to conduct meta-studies such as Smith and Huang (1995) or Carson et al. (1996). Recent hedonic work has tended to emphasize use of actual sales data rather than the Census reports of an earlier generation of studies. Much of this literature has focused on environmental disamenities such as poor water quality (Michael, Boyle, and Bouchard 1996), hazardous waste sites (Kiel 1995), high voltage lines (Hamilton and

Schwann 1995), or oil refineries (Flower and Ragas 1994). In many studies, the environmental service being valued is proximity to the service-source, not the service itself.

There has been a flurry of research on the concept and conduct of CVM studies, brought about in part by the enormous (by academic standards) investment in economics research by law firms involved in the *Exxon Valdez* accident and the State of Alaska's damage claims (Arrow et al. 1993; Hausmann 1993; Portney 1994). This has led to several strongly worded exchanges in the literature and in court.

There is no simple way to access this vast literature. Perhaps the reader is best served by turning immediately to compilations such as Bromley (1995), Kopp and Smith (1993), or Willis and Corkindale (1995). Any of these serve well as a starting point.

Recommendations

Good economic valuation studies can be time-consuming and expensive, just as are good biological or hydrographic studies. Even the existence of some short-cut or cookbook valuation techniques do not relieve resource managers of the necessity to understand more about economic theory and empirical techniques. Nor are there shortcuts possible when it comes to knowing the data and the physical science that links the environmental asset to changes in human well-being.

Nonmarket valuation studies by their nature are sometimes subject to ridicule because their subject is not "real." This is a severe misconception. All economic valuations, whether for environmental services such as air quality or for more physical assets such as baseballs, involve the implicit or explicit assignment of prices to services from an underlying asset. Economists never value the asset itself, just as consumers never desire the asset itself.

Some readers of this *Methods Review* are likely, someday, to be buyers of economic valuation research. We offer to them the same advice that we would if we were biologists or hydrologists. Good economic valuation studies are neither simple in concept nor cheap in practice. A too casual study is worse in many cases than no valuation study at all!

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28

Climate Impacts and Adaptation Assessment

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Abstract

This essay comments on the integrated impacts assessment modeling approach which dominates climate impact assessment currently and concludes that a modeling approach alone is limited in producing useable information for policymakers. Methodological frameworks that use some modeling information but also incorporate other empirical methods are reviewed. In particular, the “stakeholder driven” integrated assessment framework developed for the Canadian Mackenzie Basin Impact Study is recommended both for developed and developing country climate impact assessments.

Key Words: climate change, global warming, climate impact assessment, integrated impact assessment model, greenhouse policy

Climate Impact Assessment—A Developing Field

Climate impact assessment is a rapidly developing field of impact assessment. It is an essential tool in policy formulation to address the problem of human induced climate change (Taplin and Braaf 1995). To date, climate impact assessment has been most often implemented as part of a “linear” process in “ ‘response’ to climatic change projections: predictions have been followed by impacts assessment and, finally, by policy development” (Henderson-Sellers and Braaf 1996). This approach has been subject to criticism because uncertainties increase markedly as progression is made from climate science to impact assessment and, in turn, to policy response research. In this review chapter, some promising approaches to climate impact assessment currently being trialed that do not follow the “linear” approach and also incorporate the active involvement of stakeholders (users of climate impacts information) in the assessment process are discussed. These approaches are directed towards producing usable climate impacts information for the policy process both at the domestic and international levels.

Development of response policies to address global change is challenging due to the transnational aspect of both the origins and impacts of global change and the uncertainties in the scientific knowledge base. Nevertheless decision makers at local, national, and global levels are seriously looking for policy directions.

At the international level, the key policy instrument is the UN Framework Convention on Climate Change (FCCC). This treaty does not yet have any binding targets or timetables for greenhouse gas emissions reduction but does require developed nations to aim to stabilize CO_2 emission levels at 1990 levels by 2000 and to formulate and implement national greenhouse policies. It was prepared for signing at UNCED (United Nations Conference on Environment and Development) in Rio in 1992, had its First Conference of the Parties (CoP) in Berlin in February 1995, and its Second CoP in Geneva in July 1996. The Third CoP is planned to be held in Kyoto, Japan in 1997. The

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Convention has now been ratified by over 120 nations who are committed to addressing the problem of global warming. Currently, the process is directed towards negotiation of a legal instrument, or protocol, that is expected to incorporate emissions reduction targets for developed nations.

The FCCC requires a dual approach to policy making through formulation and implementation of adaptation and mitigation strategies. A *mitigation* approach involves the implementation of actions to hinder or slow the trend of global change (for example, reducing fossil fuel use or offset options such as engaging in reafforestation to enlarge existing carbon sinks) (Braaf et al. 1995). *Adaptation* options allow or encourage human and ecological systems to adjust or adapt to new global climatic conditions or events, to offset negative impacts, and to take advantage of positive impacts that could result from global climate change (Braaf et al. 1995).

Since 1988, the Intergovernmental Panel on Climate Change (IPCC) has been involved in coordinating the scientific and technical assessment results from climate change researchers around the globe. This scientific and technical assessment work has arguably become an important resource for the Convention negotiations. Expert information from the IPCC about climate change is supplied to the CoP via the FCCC Subsidiary Body for Scientific and Technological Advice (SBSTA). The IPCC process of synthesising the work of hundreds of researchers involves lead authors, workshops, plenaries and independent refereeing. The IPCC currently has three major working groups focusing on:

- Science (Working Group I)
- Impacts, adaptation, and mitigation options (Working Group II)
- Economic and social dimensions of climate change (Working Group III).

To date, two major IPCC assessment reports have been produced in 1990 and 1995 together with a supplementary report in 1992. A third IPCC assessment, currently being planned, is expected to be completed by 1999.

In the IPCC's 1995 Second Assessment Report, Working Group I made the significant announcement that, since 1990, "...considerable progress has been made in attempts to distinguish between natural and anthropogenic influences on climate" and that "the balance of evidence suggests a discernible human influence on the global climate" (IPCC WGI 1995). The expectation of significant climate change in regions around the world over the next few decades thus has been formally acknowledged by the IPCC. This is notwithstanding the existence of uncertainties such as the noise of natural variability, land surface changes, and the time-evolving pattern of forcing by greenhouse gases.

Climate impacts reported on in the IPCC's 1995 Second Assessment Report include those associated with forests, deserts and desertification, mountain ecosystems, aquatic and coastal ecosystems, hydrology and water resources, agriculture and human settlements (IPCC WGII 1995). IPCC research continues currently. In the impact assessment area, a co-ordinated series of technical papers was in preparation to be delivered in February 1997 on the subject of Regional Impacts of Climatic Change for SBSTA. Regions to be reported on were:

- Caribbean
- Equatorial South America
- Temperate South America
- Mediterranean
- Temperate Northern Hemisphere (Europe and North America)

- Northern Africa
- Southern, Central, and Eastern Africa
- Central Arid Asia
- South Asia
- Southeast Asia
- Temperate East Asia
- Oceania.

This information is important for decision making in the Convention process in terms of indicating the nature, seriousness, and timing of expected climatic change in various regions around the world.

Climate impact assessment arguably is becoming an essential component of the policy-making process both at the domestic and international levels. Currently, a considerable volume of climate impact assessment work has been carried out worldwide and this information is, for the most part, being communicated via the IPCC. Much of this work is based on a modeling approach to a variety of human or natural systems or sectors. However, for information to be useful for policymakers climate impact assessments need to be focused on all the integrated impacts of all the sectors in a region.

Recent Approaches to Climate Impact Assessment

The Modeling Approach to Integrated Assessment

The modeling approach to climate impacts assessment work is overviewed in Carter et al. (1994), Mendelsohn and Rosenberg (1994), and IPCC WGIII (1995). In general, integrated assessment models are focused on as the generic method for climate impact assessment.

Mendelsohn and Rosenberg (1994) conclude that the challenge with integrated climate assessment models is that they aim to organize vast quantities of technical information across disciplines "to provide defensible answers." They express the opinion that "Integrated [model] assessments of climate change impacts on regional and global economies are in their infancy and no one model yet exists that can be recommended for general use (Mendelsohn and Rosenberg 1994). Also, Morgan and Dowlatabadi (forthcoming) state that "Integrated assessment [modeling] is neither an end in itself, nor a one shot proposition. The most useful results from doing integrated assessment will typically not be 'answers' to specific policy questions. Rather they will be insights about the nature and structure of the climate problem, about what matters, and about what we still need to learn." Similarly, the IPCC WGIII (1995), Shackley and Skodvin (1995), and Cohen (1995, 1996) have expressed reservations about the current emphasis on modeling and its limitations in producing usable knowledge for policymakers. The IPCC WGIII (1995) report, in its chapter overviewing and comparing integrated assessment of climate change, concludes with regard to integrated assessment models: "A number of approaches are being pursued...each modeling team has chosen to focus on different aspects...At this point in time, the significant complexities and uncertainties associated with the operation of the climate system, and how it impacts and—is impacted by—human activities, make it impossible to know exactly what to focus on and what methodology to employ." The report also says "it is not clear which approach today would lead to that ultimate [impacts] model. This once again suggests the efficacy of pursuing a multitude of alternative analytic approaches to the study of climate change" (IPCC WGIII 1995).

The Framework Approach to Integrated Assessment

One promising alternative approach is to utilize some model information but not to rely wholly on a modeling approach. The prime example of this approach to climate impact assessment can be found in the Canadian Atmospheric Environment Service's (AES's) climate impacts studies. The Environmental Adaptation Research Group of the AES initiated two six-year studies: the Mackenzie Basin Impact Study (in association with the Sustainable Development Research Institute, University of British Columbia, to be completed in 1996) and the Great Lakes-St. Lawrence Basin Project (in association with the Institute for Environmental Studies, University of Toronto; due to be completed in 1997). The approach taken for these studies has been to promote integration via workshops, round-tables, models, and other assessment activities that combine information from the bio-physical and socio-economic disciplines (Cohen 1995, 1996; Mortsch, Koshida, and Tavares 1993; Mortsch and Mills 1996). Importantly, stakeholder involvement has been a key driving force in these assessments.

The Mackenzie Basin Impact Study

Much can be learned from the Canadian Mackenzie Basin Impact Study. It is a pioneering example of integrated climate impact assessment work directed towards producing knowledge that can be used in the policy process. The aim of the study was to produce an integrated regional assessment of climate change for the whole watershed, including terrestrial and freshwater ecosystems and the human settlements that depend on them (Cohen 1996). The Mackenzie Basin is the tenth largest watershed in the world, having an area of 1.8 million square kilometers and which covers parts of British Columbia, Alberta, Saskatchewan, the Yukon, and the Northwest Territories. Employment in the region is focused on agriculture and forestry, hydro-electricity production, transportation, non-renewable resource extraction (fossil fuels and mining), tourism, and government activities. Many of the indigenous people of the region are also dependant on the hunting of wildlife and fishing for both their own food uses and for their livelihoods. Advice from stakeholders (representatives from business and industry, government agencies, environmental groups, and indigenous people) was sought to assist in determining sub-project selection and major policy concerns for the region (Cohen 1995).

Cohen (1996) identifies two types of integration in the study: vertical and horizontal. Initial vertical integration came from stakeholder participation. Early in the study in 1992, a workshop was held with stakeholders to identify policy issues that might be affected by climate change and thus would be relevant to an impact study of the region. Horizontal integration involved linking scientists and social scientists from different disciplinary backgrounds in a common framework. Again, an initial workshop was held in 1992 to identify data requirements of study and to identify linkages between the sub-projects. Two subsequent workshops that used a round-table process with stakeholders were held midway through the study in 1994 and at the end in 1996. Experiences with integration were not all positive.

The final workshop, held in May 1996 in Yellowknife, capital of the Northwest Territories in the heart of the study region, was a forum for presenting final impact assessment results and seeking reactions from stakeholders in the Mackenzie basin region through a series of round-table discussions. These round-tables focused on: interjurisdictional water management, sustainability of ecosystems, economic development, maintenance of infrastructure, and sustainablity of native lifestyles. The workshop also explored whether the assessment had produced usable policy relevant information

from the point of view of the stakeholders.
Cohen (1996) makes important recommendations for "others who dare to integrate." He suggests:

- Explicit data needs for sub-projects need to specified before sub-projects are approved
- The support of a full-time secretariat for a study of this magnitude
- A common platform for GIS among researchers
- Use of spatial analogue data from regions outside the study area that have climatic conditions resembling the conditions suggested by climate scenarios (despite the fact that this approach adds uncertainties)
- Stakeholder collaboration should be implemented in the pre-research phase
- Personal contact between scientists as well as with stakeholders cannot be substituted for and frequent informal meetings should be encouraged and supported
- Modeling approaches should be complemented by direct interaction between scientists and stakeholders so that local and indigenous knowledge can be incorporated.

The final report of the Mackenzie Basin Impacts Study will be published by 1997 and will be worth waiting for. Much can be learned from this trail-blazing work.

Climate Change Integrative Assessment Process and the Climate Impacts Assessment Cube

Further analytical approaches to climate impact assessment have been recently developed in Sydney, Australia at the Climatic Impacts Centre, Macquarie University. These are the Climate Change Integrative Assessment Process (Braaf, Howe, and Taplin 1995) and the Climatic Impacts Assessment Cube (Henderson-Sellers and Braaf 1996).

Climate Change Integrative Assessment Process

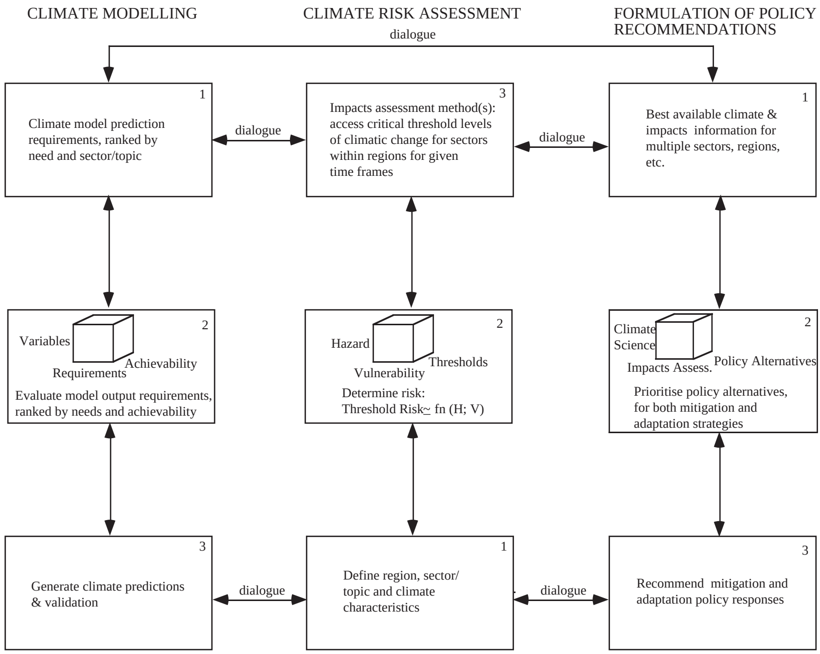
The Climatic Impacts Centre, in association with the Australian Department of Environment, Sport and Territories (DEST), developed in 1994-1995 a methodological framework for identifying adaptation policy responses to climatic change for individual sectors, on a region specific basis, within Australia (Braaf et al. 1995). This approach has been responded to with particular interest by the small but growing field of climate change policy researchers internationally.

The climate change policy research carried out in the Climatic Impacts Centre to date has shown that formulation of responses is hampered by the pervading uncertainties associated with regional climate scenarios, integrated impacts assessments, and understanding of the social, economic, and environmental systems which will shape the outcome of both impacts and responses. As a response to these concerns, the Climatic Impacts Centre researchers built on their adaptation policy approach and developed a Climate Change Integrative Assessment Process that incorporates both mitigation and adaptation responses (Braaf, Howe, and Taplin 1995) (see Figure 1). A major aim of this process is to make explicit the expert judgments made at each step in the climate change policy-making process. If policymakers are made as fully aware of the decisions, compromises, constraints, and limitations contained in each sub-component of the integrated assessment process, then more informed understanding and appreciation of the uncertainties involved will eventuate. Three current projects within the Climatic Impacts Centre are utilizing this methodological approach:

- The implications for the insurance industry due to bushfire and flood impacts in Australia

- Aboriginal health and climate change in the Northern Territory
- Joint implementation of the climate convention: development of policy beneficial to New South Wales and the Ganges Basin region in India.

Figure 1. Climate Change Integrative Assessment Process



Climatic Impacts Cube

The Climatic Impacts Cube methodology uses four criteria or axes as a framework to consider impacts and possible responses to climate change (see Figure 2) (Henderson-Sellers and Braaf (1996). These criteria are:

- Vulnerability
- Climatic hazard
- Benefit/cost ratio
- Time scale (of changes, impacts, and responses).

Sectors are the focus of the approach and when several sectors are assessed for a region then cross-sectoral comparisons can be made (see Figure 3). Questions examined include: "(1) how do we measure vulnerability? (2) how vulnerable is this sector/process/ population now? (3) what specific aspects (triggers) of climate are critical? (4) where do vulnerabilities lie (in space) and evolve (in time)? (5) how much would this response (adaptation and/or mitigation) cost? (6) if implemented sooner/later, would it help/cost more/less?" (Henderson-Sellers and Braaf 1996). Henderson-Sellers and Braaf (1996) say that if these questions are "correctly posed and fully answered" then cross-national comparisons of sectors, impacts, and responses could be carried out. They also suggest that this could give some indication of how pressing the need is for more accurate regional climate predictions.

The Climate Cube and the Climate Change Integrative Assessment Process offer innovative approaches in the climate impact assessment field. Further explicit incorporation of stakeholder involvement would enhance these approaches.

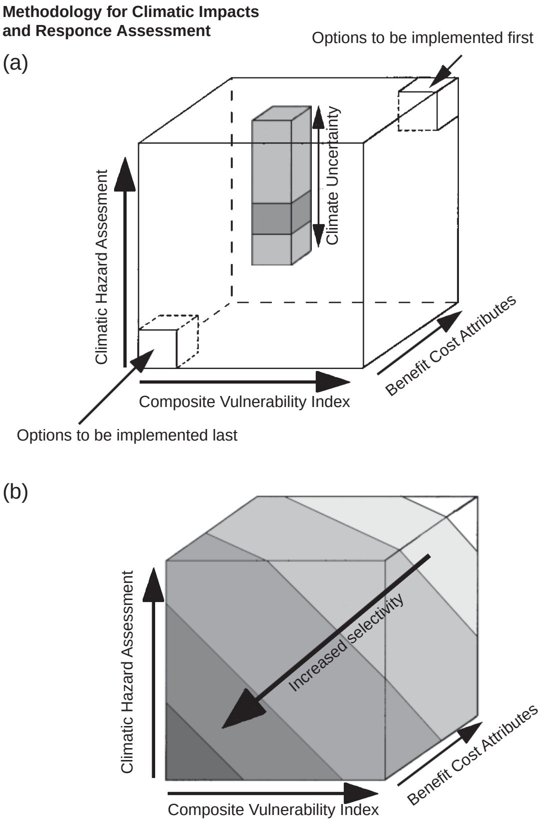


Figure 2. Example (a): The climatic impacts assessment cube. At a single point in time the three axes (criteria) for assessment are (1) climatic hazard, (2) vulnerability, and (3) benefit-to-cost ratio. Responses (adaptation or mitigation) that should warrant consideration for immediate implementation cluster at the top right-hand corner of the cube and have characteristics such that climatic hazard is well known and considerable, the vulnerability is large and well quantified and there is a demonstrably positive and large benefit-to-cost ratio. Options to be implemented last, or not at all, on the other hand, lie at the lower left-hand corner of the climatic impacts assessment cube. Example (b): The decisions about responses are not as clear cut as suggested by (a). It might be better to think of response strategies as being chosen in the light of an arrow of increased selectivity which points from the top right-hand corner (desirable options) to the lower left-hand corner (least desirable) (from Henderson-Sellers and Braaf 1996).

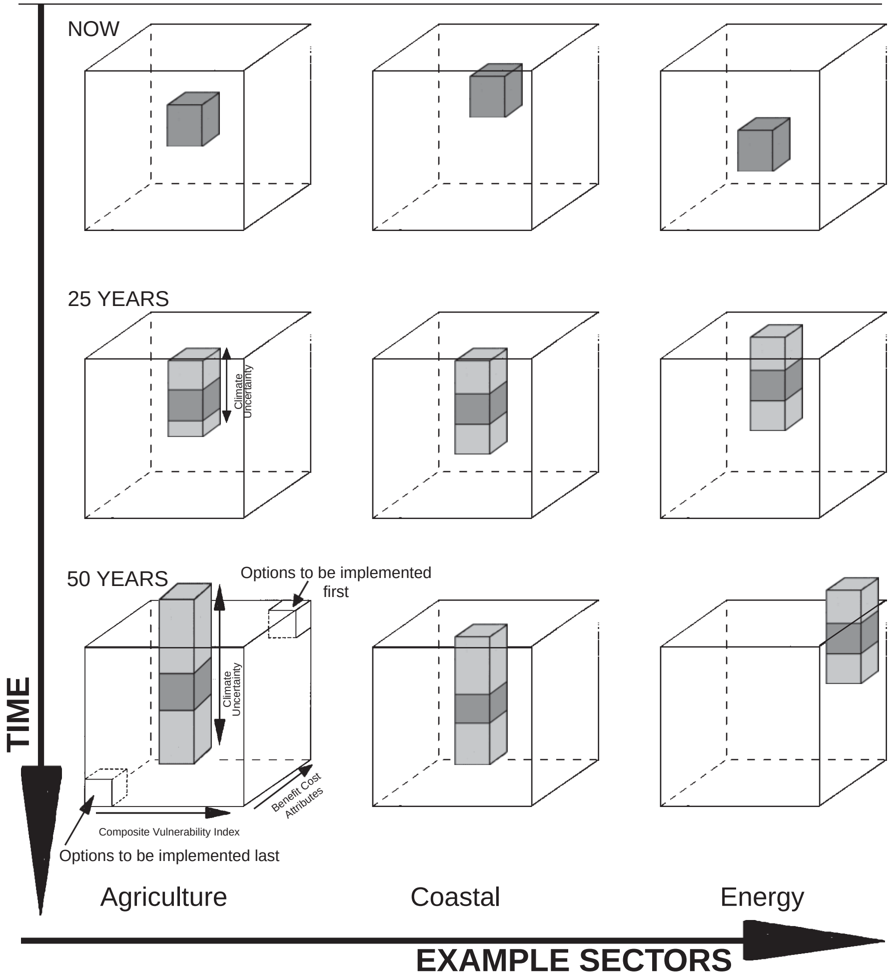


Figure 3. Different sectors will place options in different locations in 'their own' climate assessment cubes. The two-fold challenge for climatic impact evaluation and response is (1) to develop a quantitative means of cross-sectoral comparison and (2) to focus at least part of future greenhouse "science" research on the prediction uncertainities that matter for impacts and responses (from Henderson-Sellers and Braaf 1996).

Climate Impact Assessment in Developing Nations

Recently released climate impact assessment work carried out in developing countries is that of Strzepek and Smith (1995). The assessments in Strzepek and Smith's report (1995) take a modeling approach and were funded by the U.S. Environmental Protection Agency for a three-year period. Over 150 scientists from developed and developing nations were involved in this research. Principal investigators for the assessments were from the United States and the United Kingdom, and they worked in collaboration with scientists from developing nations and sought input from local, regional, and national decision makers. Potential impacts on coastal resources, agriculture, rivers, health and vegetation were examined in many nations (three) together with an assessment of integrated climate change impacts on Egypt. Overall the studies found "...significant vulnerability of developing countries to climate change"; that "climate change could cause developed countries to fall farther behind developed countries"; that "not all impacts in developing countries would be negative"; and that "taking action to anticipate climate change could further reduce vulnerability...But, these adaptive investments will consume resources that could have gone to other uses and may still not restore societal welfare to conditions that would prevail if climate change does not happen" (Smith et al. 1995). All these U.S. initiated studies, including the integrated climate impact assessment for Egypt, in their modeling approach used global climate models assuming a doubling of CO_2 in the atmosphere by the middle of the next century as a basis for creating regional climate change scenarios. The regional scenarios were then used for modeling the integrated climate change effects. The methodology adopted is shown in Figure 4. Sectoral sub-model results that feed into the integrated assessment model are from Egyptian Agricultural System Model, IIASA Basic Linked System for world food supply, sea-level rise model, population economics model, Nile runoff model, and climate scenarios. No feedback linkages were accounted for.

The Egyptian climate impact assessment is a well executed piece of model-based research but its output has limitations as usable knowledge for immediate policy decisions or for those over the next ten years.

In addition, it appears that involvement of local stakeholders could have been more fully incorporated. Only two local scientists (Lofgren, American University of Cairo, and Saleh, Cairo University) and two government agency officials (Attia, Ministry of Public Works and Water Resource, and Eid, Ministry of Agriculture) are cited as having collaborated in the research. Other stakeholders from government agencies, business, industry, and community groups do not appear to have been involved.

Unfortunately, the uneven socio-economic situation of those in developed nations compared with those in developing nations extends into the field of climate science and climate impacts assessment. This has been demonstrated in the IPCC process and is discussed in Henderson-Sellers and Braaf (1996). Nevertheless, impacts assessments should involve stakeholders in the regions and communities that are being assessed. It is essential therefore that the policy issues focused on in climate impact assessments are carefully sought from the local communities being studied. Otherwise impacts assessments implemented by developed nation researchers may be limited in usefulness for developing country policymakers.

Promising Approaches and Their Applicability

Mitigation and adaptation policy responses need to be based on thorough integrated climate impact assessment research for particular regions and sectors within regions in collaboration with stakeholders from these regions. It is important that a "stakeholder driven" climate impact assessment approach be adopted for developed countries, developing nations, and countries with economies in transition. As Henderson-Sellers and Braaf (1996) have observed about Southern Hemisphere developing nations: "...the Southern Hemisphere developing nations are the 'consumers' of information generated in the Northern Hemisphere but have little or say about its value (or lack of value) to them." The stakeholder approach adopted in Canada is very promising in its approach.

Cohen (1995) has commented, "Two factors contribute to the weak science-policy link in the climate change issue. The first is poor communication with other stakeholders

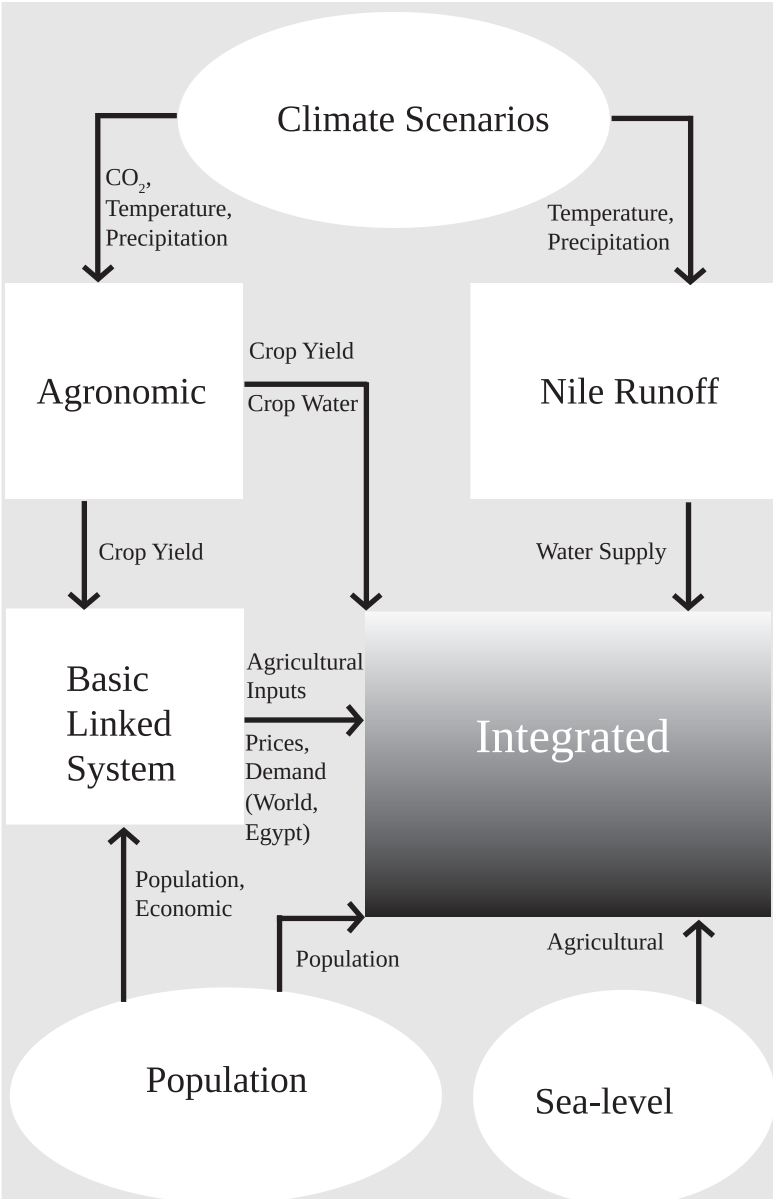


Figure 4. Schematic of integrated assessment framework showing sectoral model linkages (from Strzepek et al.1995).

[apart from scientists]. The second is a research orientation that emphasizes resolving uncertainties about climate change itself without making a corresponding effort to address the broader aspect of resource management, socio-economic shifts and policy." Necessary steps that should be included in climate impacts and adaptations assessment are:

- Definition of regions and issues
- Establishment of integrated frameworks for study of the regions
- Establishment of working committees, including stakeholders for regions and sub-committees for sectors within regions
- Identification of policy issues by stakeholders
- Identification of climate scenarios
- Identification of sectoral impact studies needed for regions (and data already readily available)
- Workshops between scientists, impacts assessors, and stakeholders
- Horizontal integration of sectoral impact assessment findings
- Development of adaptation responses.

These steps, of course, are not mutually exclusive. Also, the funding of such regional climate impacts and adaptations studies is a critical question, especially for developing countries. In developed countries both public sector and private sector funds would need to be accessed. In developing countries, funds from the Global Environmental Facility which is entrusted under the FCCC process to mobilize and distribute funds and other international agencies would need to be accessed to support the assessments.

Climate impact assessment arguably is becoming an essential component of the policy-making process both at the domestic and international levels. Currently, a considerable volume of climate impact assessment work has been carried out worldwide and this information is for the most part being communicated via the IPCC. Much of this work is based on integrated assessment modeling—a modeling approach to a variety of human or natural systems or sectors. However, for information to be useful for policymakers, climate impact assessments need to be focused on the integrated impacts of all the sectors in a region. Strzepek et al. (1995) have advocated this and say "climate change impacts can affect all of a society, and the total impacts on a society must be investigated systematically." Stakeholder participation in climate impact assessments, incorporation of model data together with other environmental, social, and economic data, and promotion of communication via round-tables and workshops appear to be the keys to success in producing usable knowledge for policymakers.

Postscript: Incorporation of Climate Impact Assessment in EA and SEA

To date, climate impact assessment has been neglected in environmental assessment (EA) of policies (see Bailey and Renton, this volume) and in strategic environmental assessment (SEA) (see Buckley, this volume). This is not surprising, as climate impact assessment is a relatively new endeavor and methods generally have not been developed by members of the broader environmental impacts assessment community. Integrated climate impacts assessment modelers often have an atmospheric science or similar background. Nevertheless, incorporation of climate impact assessment in EA and SEA is an important challenge that needs to be taken up if these impacts assessment approaches are to be comprehensive. Dialogue between those involved in climate impact assessment and those in the fields of EA and SEA is an essential starting point. Also, when climate impacts assessors begin to be involved in contributing to EA and SEA projects, they will potentially gain insights from their involvement that should help in developing better methods for climate impact assessment.

Endnotes

1. Argentina, Bangladesh, Brazil, China, Egypt, China, Egypt, India, Malaysia, Mexico, Nigeria, Pakistan, Phillipines, Senegal, Thailand, Uruguay, Venezuela, and Zimbabwe.

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29

Public Health in Environmental Assessments

Reiner Banken[1]

Abstract

Human health concerns play a central role in environmental decision making. There is a recent tendency to apply the public health model of health determinants to environmental assessments. Public health impacts are increasingly studied not only through toxicological risk assessment but also through microbiological risk assessment and through the study of psychosocial determinants of health.

Key Words: human health, public health, health determinants, risk assessment, social impact assessment

Background

From the very beginning of environmental assessments, the safeguard of human health was supposed to be a goal of importance equal to the preservation of the natural environment. The U.S. National Environmental Policy Act of 1969 (NEPA) states as one of its purposes the promotion of efforts "which will prevent or eliminate damage to the environment and biosphere and stimulate the health and welfare of man" (NEPA 1969, Sec 2). In the practice of environmental assessments, human health considerations were either ignored or given only superficial attention during the 1970s (Go 1988). The regulatory focus of the "Regulations for Implementing the Procedural Provisions" of NEPA, promulgated in 1978, was placed on environment rather than people (Mauss 1994). Mauss speculates on this evolution of the US framework of environmental assessments by pointing out that, by the time these regulations were written, "EPA had become the guardian of human health, and NEPA the protector of the environment."

Although human health considerations have become a specific part of most legislative frameworks on environmental assessments all over the world (Sutcliffe 1995), and though the normative literature on impact assessment considers social and health aspects an integral part of EA, they are frequently left out in real life projects (Ortolano and Shepherd 1995). This paper discusses the scope and methods used in examining health impacts in EA, to explain its practice on the basis of some specific features of public health that are different from other disciplines in EA, and to point out some of the recent developments in this area.

Scope and Methods of Environmental Health Impact Assessments

From the beginning of modern public health in the nineteenth century, the physical environment has been considered to be one of the main determinants of public health. The increase in the number of health interventions on an individual level such as vaccinations and modern treatments have generated a progressive decline of public health community's interest in environmental interventions, which reached a peak in the 1970s

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(Ashton and Seymour 1988). The relative importance of environmental interventions of public health declined sharply during this period. With the beginning of the 1980s, a renewal in public health started and gained enough momentum to be called the New Public Health (BMJ 1988). This conceptual renewal has placed great importance on the physical and social environment as major determinants of human health. At the World Health Organization (WHO), the movement towards the physical environment as a health determinant gave rise to different publications starting in the 1970s in order to develop the knowledge base to a branch of public health which became known as environmental health (WHO 1972, 1976). In subsequent years, numerous publications have addressed the issue of environmental health.

In 1986, WHO held a meeting on the health and safety component of environmental impact assessment. The report of this meeting was one of the first to address specifically the issue of human health in EA. The expert group proposed to use the risk assessment and mangement process in order to study the future health effects of projects:

> Chemical risk management is designed to be applied to chemicals without reference to a specific project context, often directed to the setting of regulatory or advisory exposure limits or other controls. The health and safety component of EA is concerned with, among other things, the health effects of chemicals within project or policy appraisal as part of the permitting procedure for that development. Chemical risk management (WHO model) and the assessment of environmental health effects are closely related, but they are different procedures for different purposes (WHO 1987: 2).

The choice of the risk assessment and management process at that time was not aimed to limit the scope of health impacts to its toxicological aspects. The authors made a pragmatic choice based on the availability of risk assessment as a specific methodology for health. They made the explicit statement that social determinants of health should be included in EA:

> The health component of EA should include not only disease-related effects but also all impacts which might change the well-being of neighbouring populations whether it be for better or worse. These might include psychological effects of proximity of certain types of development and improvement in health as a result of increased employment and wealth in a community (WHO 1987: 9).

These statements from 1987 still apply to contemporary methodology of Environmental Health Impact Assessment (EHIA) as a specific part of EA. As Ortolano and Shepherd (1995) have pointed out, EHIA is frequently absent even for projects with significant human health impacts. Considerable efforts have been undertaken on an international scale to propose and promote the risk assessment based EHIA process (Turnbull 1992). Go (1988) points out some methodological difficulties in applying the risk assessment process to health determinants outside the toxicological aspects :

- Secondary health and socio-economic effects are ubiquitous in all projects of significance that affect population growth and movements.
- These types of impact are generally subject to exogenous events that are probabilistic or undeterminable.
- [...] "because of the stochastic nature of physical and biological processes and the fact that the most important health consequences are frequently dependent on undeterminable or probabilistic factors and exogenous events," the quantification of human health is extremely complex.

According to Go (1988), the complexity of the relationships between health risks from toxicological and microbiological sources and health protective factors of economic and social development makes it impossible to construct coherent quantitative models in order to predict the overall impact of a project on the health of a given population. However, even if it is impossible to construct such holistic quantitative models, why does public health not seem to get involved in any of the social determinants of health as suggested by the WHO in 1987? Part of the answer may lie in the basic characteristics of public health and its evolution in the last twenty years.

Public Health and New Public Health

Public health has been defined as "efforts organized by society to protect, promote and restore the people's health" (Last 1988). This definition contains the notion of socially organized actions towards the common goal of population health. In recent years, considerable work has been done in different countries to reorganize the public health actions, starting on a conceptual level and leading to restructuring of public health systems (Institute of Medicine 1988; Committee of inquiry 1988; PAHO 1992). The resulting conceptual renewal has lead to a dichotomy between the traditional public health concerned with the control of health risks using a risk assessment and management strategy (CHPB 1990) and the new public health based on the concept of health promotion concerned with reinforcing the individual and the collective potential for health (Abelin 1991). This dichotomy can be characterized as two opposing public health subcultures, each with its specific paradigm of values and methods (Walker 1995).

Environmental health impact assessments have evolved inside the health protection tradition in the field of environmental health. Environmental health is concerned with controling health risks associated with the physical environment (HEADLAMP 1995). There is, however, a subtle difference between risk assessments and environmental health assessments. The Agency for Toxic Substances and Disease Registry (ATSDR 1992) states that "deliberate differences exist between ATSDR's health assessments and EPA's risk assessments...The product of quantitative risk assessment is a numeric estimate of the public health consequences of exposure to an agent...ATSDR health assessments are based on environmental characterization information, community health concerns, and health outcome data." While risk assessment is concerned with producing knowledge about health risks, environmental health assessment uses this knowledge and inserts it into the specific context of a community in order to implement specific public health activities. This context specificity of a public health approach permits an organic integration of community values and perceptions into environmental decision making (Burke 1996).

Health promotion has emerged as a new public health strategy during the 1980s. Its driving force has come from the WHO movement Health for All by the year 2000 (WHO 1981). In order to achieve this goal, strategies of reducing inequities, increasing prevention, creating healthy environments, fostering public participation, coordinating healthy public policy, and empowering people to control their environment have emerged (Abelin 1991). An international conference in Ottawa served to establish principles and guidelines for health promotion strategies (WHO 1986a). The framework of health promotion has become so prominent and dynamic that the term "New Public Health" has been coined to describe this renewal process in public health thinking, intervening, and researching (Ashton and Seymour 1988; Dean 1994). This new public health is stressing the importance of acting on the collective determinants of health in order to achieve a better health status for populations worldwide. The individual lifestyle approach of health education has been expanded to include collective elements like the physical and social environment and public policies. The change towards health promotion has been established through expert consensus conferences like the one in Ottawa in 1986. The knowledge base for applying this framework coherently is, however, still not strong enough to give a scientific underpinning for many of today's health promotion programs and actions. During the last few years, efforts have been made to establish research methods to create the knowledge necessary to support health promotion actions (Dean 1994).

The main strategies of the new public health movement have been process-oriented towards a planned sociopolitical change by creating healthy environments and healthy public policies (McKinlay 1993). They emphasize action on health determinants through intersectoral action, advocacy, empowerment, capacity building, community development, mobilization, and participation (Abelin 1991; WHO 1986a, b; CPHA 1996). Pederson et al. (1988) have shown the current conceptual weakness of the health promotion framework for integrating the multiple interventions and objectives of public health towards a unified sociopolitical change. Draper (1995) proposes Health Impact Assessment as a tool for influencing public policies in a rational way, for "putting the pieces together." This proposed health impact assessment process is seen by its proponents as a separate tool from the existing EA frameworks (Frankish et al. 1996). The framework of strategic environmental assessments which examines the environmental and, as such, public health consequences of policies, plans, and programs could be an ideal terrain for developing and integrating Health Impact Assessments. Connections beween both fields seem, however, non-existent for the moment.

For the purpose of the present discussion, it is important to recall that public health is undergoing a conceptual renewal process, with a shift underway from the conventional practice of public health that concerns itself with the control of health risks and which is based on epidemiological, toxicological, and microbiological knowledge to the new theory and practice of public health which integrates aspects of social science, thus departing from the traditional knowledge base. The new concept of public health possesses a much stronger focus on social action and social development than did its predecessor.

From Environmental Health to Public Health Assessments

The human health aspects of EA have evolved inside the health protection framework of environmental health, limiting its practical scope and methodologies to the assessment of toxic risks of projects. Two types of tendencies have emerged in recent years. Both aim at enlarging the present practice of assessing the human health consequences in EA towards the social determinants of health. One tendency is coming from inside the health protection tradition, the other from the health promotion movement.

Birley (1995) has contributed to enlarging the health protection framework to include the risk of infectious diseases and accidents for development projects. He is proposing detailed guidelines on how to take these considerations into account. Concerning psychosocial dimensions, he states that "mental disorder may be associated with the stress of new ways of living and the disruption of long established communities" (Birley 1995: 9). He does not propose any methodologies to take into account these factors in the public health assessment procedure. CSEQ (1993) has included a chapter on social impact assessment into a training manual for public health professionals. However , they did not propose any treatment of social aspects specific to public health. Health Canada (1996) is specifically working on integrating social aspects into a health assessment framework. Nationwide consultations have provided a consensus among public health professionals to introduce social aspects into the health assessment process. Methodological tools for examining the social consequences of projects have been developed for the area of social impact assessment (SIA), the public health sector is, however, mostly unaware of these specific methods and the possibility in adapting them for the psychosocial determinants of population health.

The other tendancy towards enlarging the present practice of assessing the human health consequences in EA towards the social determinants of health is emerging from the field of health promotion. In the very beginning of the health promotion movement, WHO (1986b) called for developing integrative frameworks for health risks and social aspects in health impact assessments. Ashton (1991) has coined the application of health promotion principles to environmental health "the new environmental health." Chu and Simpson (1994) elaborate on this ecological public health. They call for an integrated model of health, social, and environmental assessment. Like CSEQ (1993), they refer to existing SIA methodologies; however, they do not propose a specific framework of social aspects in public health. Proponents of the new environmental health who see EA as a practical way of enhancing public health's action towards healthy environments seem, however, to be marginal in the field of health promotion.

This evolution of public health concepts in EA can be explained by the move from the traditional public health concerned with bio-physical risks to health towards the new public health which gives a much stronger emphasis on action on the psychosocial determinants of health. For the field of environmental assessments, this evolution is, however, producing a confusing terminology of environmental health (impact) assessment, health (impact) assessment and public health (impact) assessment. The discussion of whether or not to include the term impact should be held at another level. The above discussion on the evolution of health concepts in environmental assessments favors replacing the term *environmental health assessments*. An alternative should be either *public health assessment*, or, as the adjective *public* may be more confusing than enlightening, the term *health assessment*.

Conclusion

We have seen the specific place most legislative and regulatory frameworks of EA reserve for human health aspects. The theoretical and normative scope of human health considerations range from toxicological health risks to the different social determinants of health. The practical scope has mostly been limited to risk assessment of toxicological elements. This dichotomy between the theoretical and normative scope and its practical application can be explained by the fact that environmental health impact assessments have evolved inside the health protection tradition of public health. The current conceptual renewal called "the new public health" is stressing the importance of acting on the collective determinants of health (environment and policies) through a process-oriented approach. Health promotion strategies acting on the psychosocial determinants of health must be integrated with traditional health protection efforts in order to arrive at a coherent participation of public health in EA. Efforts should be made to promote EA as an existing regulatory framework for all aspects of public health from health protection to health promotion. Particularly, the tendancy towards a separate health impact assessment process for examining the public health consequences of certain policies, plans, and programs must be integrated into SEA frameworks.

Traditionally, the different natural and social science disciplines have been involved in the EA process through the production of the Environmental Impact Statement (EIS). The only notable exception has been a tendency in Social Impact Assessments (SIA) called "the political approach" which places an emphasis on the social and cultural context of scientific evidence, on SIA as a strategy for community development, and on shifting the control of social research from the project proponent to the community (Craig 1990; Gagnon, Hirsch, and Howitt 1993). This school of thought in SIA presents some natural affinities with public health strategies for the social determinants of health. This natural alliance should be actively explored by public health practitioners involved in EA.

A decade after having started to integrate human health aspects into EA, public health seems finally on the move from a health protection framework to a public health framework. The assessment of toxic risks of projects is gradually giving way to a comprehensive model of health determinants integrating epidemiological, toxicological, and social science aspects. Successful insertion of health risks and social determinants of health into EA holds the promise of a high-level integration of ecological and human elements into decision making.

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Health Care Technology Assessment

Clifford S. Goodman[1]

Abstract

In this era of cost constraints, market-based health reform, and inadequate access to care for tens of millions in the U.S., technology remains the substance of health care. Decision makers increasingly demand well-founded information to determine whether or how to develop technology, allow it on the market, acquire it, use it, pay for its use, and more. Growth and development of health care technology assessment in government and the private sector reflect this demand.

Key Words: health care technology assessment, policy-making, priority setting, cost-effectiveness analysis, meta-analysis, decision analysis, consensus development

Background

Health care technology assessment (HCTA) is the systematic evaluation of properties, effects, or impacts of health care technology. The main purpose of HCTA is to inform technology-related policymaking in health care. HCTA is conducted by interdisciplinary groups using explicit analytical frameworks drawing from a variety of methods. HCTA methods are evolving and their applications are increasingly diverse.

HCTA can be used in many ways to support policy-making. Among these ways are to:

- advise a regulatory agency about whether or not to permit commercial use of a technology
- help health care payers and providers to determine which technologies should be included in benefits plans
- advise clinicians and patients about the proper use of technologies
- help hospital managers to make technology acquisition and management decisions
- advise governments about undertaking public health programs
- support health technology makers' product development and marketing decisions
- set standards regarding the manufacture and use of technologies
- advise investors and companies concerning transactions in the health care industry.

The impetus of a HCTA is not necessarily a technology. Three basic orientations to HCTA are as follows:

- *Technology-oriented* assessments are intended to determine the characteristics or impacts of particular technologies.
- *Problem-oriented* assessments focus on solutions or strategies for managing a particular problem for which alternative or complementary technologies might be used.

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- *Project-oriented* assessments focus on the placement or use of a technology in a particular institution or other designated project.

These basic assessment orientations can overlap and complement one another.

HCTA can be applied across the broad array of health care technologies. These include: drugs; devices, equipment, and supplies; medical and surgical procedures; support systems (e.g., computer-based patient record systems); and organizational and managerial systems (e.g., prospective payment using diagnosis-related groups). Technologies can also be grouped according to their health care purpose—that is, prevention, screening, diagnosis, treatment, and rehabilitation.

Technologies may be assessed at different stages of diffusion and maturity. There is no single correct time to conduct a HCTA; it is conducted to meet the needs of a variety of policy-makers seeking information throughout the lifecycles of technologies. There are tradeoffs inherent in decisions regarding the timing for HCTA. The earlier a technology is assessed, the more likely its diffusion can be curtailed if it is unsafe or ineffective. However, to regard the findings of an early assessment as definitive or final may be misleading. HCTA increasingly is recognized as an iterative process rather than a one-time operation.

Properties and Impacts Assessed

HCTA may involve investigating one or more properties, impacts, or other attributes of technologies. In general, these include the following:

- technical properties
- clinical safety
- efficacy and/or effectiveness
- economic attributes or impacts
- social, legal, ethical and/or political impacts.

Technical properties include performance characteristics and conformity with specifications for design, manufacturing, reliability, ease of use, etc. *Safety* is a judgment of the acceptability of risk associated with using a technology in a given situation. *Efficacy* refers to the benefit (usually measured in health outcomes) of using a technology for a particular problem under ideal conditions, for example, within the protocol of a carefully managed randomized controlled trial involving patients meeting narrowly defined criteria. *Effectiveness* refers to the benefit of using a technology for a particular problem under general or routine conditions, for example, by a physician in a community hospital for a variety of types of patients.

Health care technologies can have a wide range of microeconomic and macroeconomic attributes or impacts. Microeconomic concerns include costs, prices, charges, and payment levels associated with individual technologies, as well as comparisons of resource requirements and outcomes (or benefits) of technologies for particular applications, such as cost effectiveness, cost utility, and cost benefit.

Examples of macroeconomic impacts are the impact of new technologies on national health care costs, the effect of technologies on resource allocation among different health programs, or among health and other sectors, and the effects of new technologies on outpatient versus inpatient care.

Many health technologies raise social and ethical concerns. Such technologies as genetic testing, fertility treatments, transplantation of scarce organs, and life-support systems for the critically ill challenge certain legal standards and societal norms. Ethical considerations continue to prompt improvement in informed consent procedures for patients involved in trials of investigative technologies.

Health outcome variables are used to measure the safety and effectiveness of health care technologies. Health outcomes have been measured primarily in terms of changes in mortality or morbidity.

Many health care technologies affect patients, family members, providers, and employers in ways that are not reflected in mortality or morbidity rates. Health-related quality of life (HRQL) measures (or indices) are increasingly used with more traditional outcome measures to assess health care. Various HRQL measures capture such dimensions as physical function, social function, cognitive function, anxiety/distress, bodily pain, sleep/rest, energy/fatigue, and general health perception. HRQL measures may be disease-specific (e.g., heart disease or arthritis) or general (covering overall health) (Ware 1995).

Ten Basic Steps of HCTA

There is great variation in the scope, selection of methods, and level of detail in the practice of HCTA. Nevertheless, most HCTA activity involves some form of the following steps (Goodman, Snider, and Flynn 1996), described below.

1. Identify assessment topics
2. Specify the assessment problem
3. Determine locus of assessment
4. Retrieve evidence
5. Collect new primary data (as appropriate)
6. Interpret evidence
7. Synthesize/consolidate evidence
8. Formulate findings and recommendations
9. Disseminate findings and recommendations
10. Monitor impact.

Step One: Identify Assessment Topics

To a large extent, assessment topics are determined or bounded by the mission or purpose of an organization. Most assessment programs have criteria for topic selection, although these criteria are not always explicit. Examples of selection criteria that can be used in setting HCTA priorities are:

- health problem with high burden of morbidity and/or mortality
- large number of patients affected
- high unit or aggregate cost of a technology or health problem
- substantial variations in practice
- sufficient research findings available upon which to base assessment
- need to make regulatory decision
- need to make payment decision

Processes for soliciting candidate assessment topics and ranking assessment priorities range from being highly subjective to systematic and quantitative (Donaldson and Sox 1992; Phelps and Mooney 1992).

Step Two: Specify the Assessment Problem

One of the most important aspects of an assessment is to specify clearly the problem(s) or question(s) to be addressed. This will affect all subsequent aspects of the assessment. A group conducting an assessment should have an explicit understanding of the purpose of the assessment and who the intended users of the assessment are to be.

There is no single correct way to state an assessment problem. In general, this could entail specifying at least the following elements: health care problem(s); patient population(s); technology(ies); practitioners or users; setting(s) of care; and properties/

impacts/outcomes of interest.

Step Three: Determine Locus of Assessment

Health care decision makers can “make or buy” all or certain portions of HCTAs. Determination of the responsibility for sponsoring or conducting an assessment depends upon the nature of the problem, expertise of available personnel and other resource constraints, and other factors.

Even when a HCTA report exists on a topic of interest, decision makers must determine whether it has a compatible perspective, whether the assessment problem is appropriate, how current the report is, whether the methodology is sufficiently credible, and whether the report is worth its price.

Smaller health care provider and payer organizations often obtain reports from organizations that specialize in HCTA; larger ones are more likely to have internal HCTA programs. Some health care organizations commission selected components of an assessment, such as evidence retrieval and synthesis, and perform the other steps in-house.

Step Four: Retrieve Available Evidence

One of the challenges of HCTA is to assemble the evidence—the data, literature, and other information—that is relevant to a particular assessment. For very new technologies, the evidence may be sparse and difficult to find; for many technologies, it can be profuse, scattered, and of widely varying quality. Types of evidence sources include:

- computer databases of published literature
- computer databases of clinical and administrative data
- printed indexes and directories
- government reports and monographs
- reference lists in available studies, reviews, and meta-analyses
- special inventories/registries of reports
- newsletters and newspapers
- company reports
- colleagues and other investigators.

Much valuable information is available beyond the traditional sources. This “gray” or “fugitive” literature is found, for example, in industry and government monographs, regulatory documents, professional association reports, market research reports, special commission reports, conference abstracts, and on the World Wide Web (WWW). Although the gray literature can be timely and cover aspects of technologies that are not addressed in mainstream sources, it is usually not subject to peer review, and must be scrutinized accordingly (Goodman 1993).

Step Five: Collect New Primary Data

Although many HCTAs are based on available evidence, some entail collection of new primary data. Certain attributes of primary studies produce better evidence than others. Basic types of methods for generating new data on the effects of health care technology in humans include the following:

- large randomized controlled trial (RCT)
- small RCT
- nonrandomized trial with contemporaneous controls
- nonrandomized trial with historical controls
- cohort study
- case-control study
- cross-sectional study
- surveillance (e.g., using registers or surveys)
- series of consecutive cases

- single case report.

These methods are listed in rough order of most to least scientifically rigorous for internal validity, that is, for accurately representing the causal relationship between an intervention and an outcome in the particular circumstances of a study. The demand for studies of higher methodological rigor is increasing among technology-related decision makers.

There are tradeoffs between studies with high internal validity, for example, large RCTs and those with high external validity (or generalizability), e.g., various observational studies or "natural experiments." Investigators have made progress in combining some of the desirable attributes of both. For example, while retaining the methodological strengths of prospective, randomized design, "large, simple trials" use large numbers of patients, more flexible patient entry criteria, and multiple study sites to improve external validity (Peto, Collins, and Gray 1993).

Studies of costs and related economic implications can involve attributes of either or both of primary data collection and synthetic methods. Main types of cost analysis include the following (Eisenberg 1989; Eddy 1992a; Doubilet, Weinstein, and Jones 1986).

- Cost-of-illness analysis determines the economic impact of an illness or condition, e.g., arthritis or bedsores, including associated treatment costs.
- Cost-minimization analysis determines the least costly among alternative interventions that are assumed to produce equivalent outcomes.
- Cost-effectiveness analysis compares costs in monetary units with outcomes in quantitative non-monetary units, e.g., reduced mortality or morbidity.
- Cost-utility analysis is a form of cost-effectiveness analysis that compares costs in monetary units with outcomes in terms of their utility, usually to the patient, measured, e.g., in quality-adjusted life years (QALYs) (Nord 1992; Mehrez and Gafni 1993).
- Cost-benefit analysis compares costs and benefits, both of which are quantified in common monetary units.

The approaches used to account for costs and outcomes in cost analyses can vary in a number of important respects, for example, the following:

- perspective of analysis (e.g., society, payer, provider, patient)
- accounting of direct costs (medical and non-medical)
- accounting of indirect costs (e.g., loss of productivity)
- use of charges/prices vs. actual costs
- choice of time horizon (short-term or long-term)
- use of average costs vs. marginal costs
- choice of discount rate
- correction for inflation
- use of sensitivity analysis.

Step Six: Interpret Evidence

A challenge to any HCTA is to derive credible findings from evidence drawn from different types of studies of varying quality. Assessors should use a systematic approach to critically appraise the quality of the available studies (Eddy 1992b; Goodman 1993). Evidence tables that summarize attributes of study design, patient characteristics, patient outcomes, and derived summary statistics are useful for displaying important qualities about available studies. Also, grading evidence according to its methodological rigor is increasingly becoming a standard part of HCTA (Chalmers et al. 1981; Evidence-Based 1992). It can take various forms, each of which involves structured, critical appraisal of the evidence against formal criteria.

Some analysts consider that the results of studies that do not have randomized controls are subject to such great bias that they should not be included for determining the effects of an intervention. Others say that studies with weaker designs should be used but given less weight or adjusted for their biases (Chalmers et al. 1989). Assessment groups should document the criteria or procedures by which they use studies.

Step Seven: Synthesize/Consolidate Evidence

Having considered the merits of individual studies, an assessment group must synthesize or consolidate the available findings. Methods used to combine or synthesize data include:

- non-quantitative literature reviews
- meta-analysis or other quantitative literature syntheses
- decision analysis
- group judgment or “consensus development.

Cognizant of biases inherent in traditional means of consolidating literature (i.e., non-quantitative literature reviews and editorials), HCTA programs are emphasizing more structured, quantified, and better-documented methods.

Meta-analysis refers to a group of statistical techniques for combining results of multiple studies to obtain a quantitative estimate of the overall effect of a particular technology (or variable) on a defined outcome. This combination may produce a stronger conclusion than can be provided by any individual study. Like traditional methods for consolidating literature, meta-analysis can be limited by biased selection of studies, poor quality data, insufficiently comparable studies, and biased interpretation of findings. However, the systematic approach of meta-analysis can minimize these shortcomings (Laird and Mosteller 1990; Lau et al. 1992).

Decision analysis uses available quantitative estimates to model the sequences of alternative strategies (e.g., of diagnosis and/or treatment) in terms of the probabilities that certain events and outcomes will occur and the values of the outcomes that would result from each. Decision models can be used to predict the distribution of outcomes for patient populations and associated costs of care. They can be used to help develop clinical practice guidelines for specific health problems. For individual patients, decision models can be used to relate the likelihood of potential outcomes of alternative clinical strategies or to identify the clinical strategy that has the greatest personal utility (Pauker and Kassirer 1987; Thornton, Lilford, and Johnston 1992).

Virtually all HCTA efforts involve *group judgment* at some juncture, particularly to formulate findings and recommendations. Group judgment may be unstructured and informal, or it may involve formal group methods such as the nominal group and Delphi techniques. Although these processes typically involve face-to-face interaction, some group judgment efforts combine remote, iterative interaction of panelists with face-to-face meetings (Lomas et al. 1988; Fink et al. 1984). The opinion of an expert committee does not in itself constitute primary scientific evidence.

Step Eight: Formulate Findings and Recommendations

Findings are the results or conclusions of an assessment; recommendations are the suggestions, advice, or counsel that result from the findings. Recommendations can be made in various forms, such as a set of options, a practice guideline, or a directive.

Even for those aspects of an assessment problem for which there is little useful evidence, an assessment group may have to provide some findings or recommendations. This may involve making inferences from the limited evidence, extrapolations of evidence from one circumstance to another, theory, or other subjective judgments.

In any case, HCTA report narratives should make explicit the analyses and reasoning that are used to derive their recommendations and with what level of confidence they were made. HCTA reports increasingly annotate their recommendations with different levels of strength that reflect the grades of the evidence and direction of findings pertaining to each recommendation.

Step Nine: Disseminate Findings and Recommendations

Dissemination efforts must compete with the burgeoning flow of health-related information being transmitted across diverse channels using increasingly sophisticated means. Little is known about how to optimize dissemination of HCTA findings and recommendations. Worthy findings and recommendations can be lost because of misidentified and misunderstood target audiences, poor packaging, wrong transmission media, bad timing, and other factors (Goldberg et al. 1994; Mittman and Siu 1992).

Dissemination should be planned and budgeted at the outset of an assessment along with other assessment phases or activities. However, dissemination plans should not be rigid; the nature of the findings and recommendations themselves may affect the choice of target groups and types of messages to be delivered. The results of the same HCTA may be packaged for dissemination in different formats, (e.g., for patients, clinicians, and policy analysts) and delivered via different media accordingly.

Step Ten: Monitor Impact

The impacts of HCTAs are variable and not uniformly understood. Whereas some HCTA reports are translated directly into policies with clear and quantifiable impacts, the findings of even some “definitive” RCTs and authoritative, well-documented HCTA reports go unheeded or are not readily adopted into general practice.

As is the case for the technologies that are the subjects of HCTA, the reports of HCTAs can have indirect, unintended impacts. Some of the ways in which a HCTA report could make an impact (Banta and Luce 1993) are:

- affect corporate investment decisions
- modify R&D priorities/spending levels
- change regulatory policy
- modify marketing of a technology
- change third-party payment policy
- affect adoption of a new technology
- change the rate of use of a technology
- change the organization or delivery of care
- reallocate national or regional health care resources.

The task of measuring the impact of HCTA can range from elementary to infeasible. Even if an intended change does occur, it may be difficult or impossible to attribute this change to the HCTA given concurrent events and environmental influences.

Systematic attempts to document the dissemination processes and impacts of HCTA programs are infrequent (Banta and Luce 1993), though a few have been studied in detail (Ferguson 1993). Like other interventions in health care, HCTA programs may be expected to demonstrate their own cost-effectiveness.

Conclusion

HCTA methods are evolving and their applications are increasingly diverse. Broader participation of people with multiple disciplines and different roles in health care is enriching HCTA. The heightened demand for HCTA, in particular from the private sector and from those public institutions whose technology-related policy-making are under greater scrutiny, is pushing the field to evolve keener processes and user-specific products. Like the information required to conduct most assessments, the body of knowledge about HCTA methods is not found in one place and therefore is not static. Practitioners and users of HCTA must not only monitor changes in the field, they should contribute to its development.

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31

Ecological Impact Assessment

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Abstract

The role of ecological impact assessment in operationalizing the Convention on Biological Diversity has prompted further calls for strategic approaches to ecosystem management. Integrated monitoring of biological resources remains imperative. Research on ecological indicators for impact assessment and evaluating mitigation has been active, with an emphasis on characterization of functional attributes.

Key Words: ecology, assessment, evaluation, cumulative effects, biodiversity

Background

Briefly, "ecological impact assessment" (EIA) is a formal process of identifying, quantifying and evaluating the potential impacts of defined actions on ecosystems (Treweek 1995). Assessment of ecological effects forms an important part of EIA wherever it is practiced. However, project-level EIA has often resulted in the application of ecological principles within inappropriate spatial and temporal boundaries, resulting in shortcomings which have recurred since the earliest days of the National Environmental Policy Act (NEPA). Many of the issues raised by Beanlands and Duinker (1983) in their key report appear to remain unresolved, particularly in countries which legislated for EIA more recently. These are reviewed for the U.K. by Thompson (1995) and Treweek (1996).

Strategic environmental assessment (SEA) might provide a framework for addressing ecological impacts which are falling through the project-level EIA-net. For example, as emphasized by Clark (1994), SEA provides a sensible platform for addressing cumulative ecological effects. Therivel and Thompson (1996) give a comprehensive review of the role of SEA in nature conservation, using case studies and examples from a number of countries.

Integrated ecological assessment has a vital part to play in implementing global agreements on sustainable development and the conservation of biological diversity. It demands effective information gathering, management, and assessment at all relevant scales (local to global). Rapidly developing information technologies have an important role.

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Conceptual Developments in Ecological Impact Assessment

EIA and the Conservation of Biological Diversity

The Convention on Biological Diversity has given ecologists a much clearer focus for EIA-evaluation. Measurements of biological diversity can provide uniform "currency" for quantifying ecological limits or thresholds and determining acceptable levels of change, damage or loss through development. The potential role of EIA in conserving biological diversity and delivering sustainability has been widely acknowledged. National governments are committed to inventory and monitor biological resources and to implement appropriate conservation and recovery plans and are grappling with the information needs generated by the legislation (e.g., Her Majesty's Government 1994a, 1994b). Habitats and species have been prioritized for action based on various criteria, including rarity, rates of decline, degree of threat and nature conservation importance. Much of this work constitutes, in effect, baseline ecological assessment at the national level, though it is not always acknowledged as such.

Sadler (1996) proposes a "framework approach to biological diversity" in which he emphasizes the lack of attention paid to intra-specific diversity. There has also been a tendency to neglect lower orders of organisms (Hill et al. 1996). Difficulties in deciding which components of the world's biological diversity should be prioritized for conservation have prompted considerable debate over the definition, quantification, and tradability of natural capital.

Natural Capital

Economists distinguish between "natural" and "man-made" or "human" capital. The term "critical natural capital" (CNC) has been coined to refer to irreplaceable components of natural capital. "Strong sustainability" demands preservation of CNC irrespective of its economic value compared to prospective gains in other types of capital, for example through development (Buckley 1995). Some native habitats and species are believed to be very close to the limits of CNC required for their survival, for example lowland raised bogs in Britain (Department of Energy 1994).

Replaceable or tradable components of "natural capital" represent "constant natural assets" (CNA). Overall levels of CNA must be held constant, applying a "no net loss" standard as a minimum (Gillespie and Shepherd 1995). The statutory body responsible for nature conservation in Britain (English Nature) has recently produced two research reports dealing with identification of CNC in the maritime (Masters and Gee 1995) and terrestrial environments (Gillespie and Shepherd 1995).

However, Buckley (1995) identifies flaws in the operational use of the concept of CNC in Britain, where, for most sites, protection appears to remain "conditional." There is little evidence of the principle of "inviolability" being invoked in practice and not even nationally designated nature conservation areas appear immune from development.

Scott et al. (1995) emphasize the need to derive ecological resource values which take account of functional importance in ecosystems, rather than basing valuation purely on human consumptive and non-consumptive uses.

Decisions concerning tradability of natural resources should rest on the following factors:

- The nature conservation value of threatened habitats/species
- Their local, national, and international status
- Their role in ecosystem function
- Their replaceability using existing (tried and tested) technology
- Availability of alternative/replacement sites

- Time taken for arrival at functional equivalence
- Likely success of re-establishment in the long term.

These factors also have a part to play in deciding when a "no net loss" approach is appropriate for ecological mitigation. "Replaceability" is a key concept both in determining the tradability of natural capital and in evaluating compensatory ecological mitigation (in theory and practice).

Reference Systems for Compensatory Ecological Mitigation

There has been much debate over the extent to which ecosystems and specific wildlife habitats can be re-created or created from scratch, using existing technology. It is quite possible for ecosystems/habitats to be replaceable in theory, but for failures to occur in practice. A common problem in the highly fragmented landscapes of Europe is the lack of availability of alternative sites. A recent report for *English Nature* (Parker 1995) found that, of 150 habitat creation projects, 80% failed to achieve their stated objectives.

Much research activity has focused on the equivalence of restored and natural ecosystems (or impacted and replacement alternatives). Wetlands continue to feature most often as the "model" ecosystem. The practice of compensating wetland losses through wetland construction, restoration, or enhancement has become relatively common in the U.S., where much recent research has addressed the selection and characterization of "reference" systems for functional assessment and mitigation. Bartoldus (1994), for example, describes a procedure for the functional assessment of planned wetlands to compare "impacted" and "planned" wetland areas. Papers presented at a forum on "Ecological issues in wetland mitigation" in 1996 addressed, *inter alia*, the functional equivalence of restored and natural wetlands (Simenstad and Thom 1996); the need for a regional approach to mitigation (Zedler 1996b) and the definition of equivalence (Bedford 1996); the role of reference wetlands (Brinson and Rheinhardt 1996) and the changes needed to "fix" compensatory mitigation (Race and Fonseca 1996). Zedler (1996a) summarizes the ecological issues involved in wetland mitigation in her introduction to the forum.

Applications

Getting to grips with cumulative ecological effects

Ecosystems are exposed to a wide range of "stressors," an increasing number of which can be attributed to development actions. Failure to regulate the collective, or overall impacts of multiple threats is common. It can cause ecosystems to become stressed to the point where their ability to absorb impacts or recover from them is exceeded. Attempts are now being made to tackle cumulative threats and impacts and to operationalize some of the theoretical principles of cumulative effects assessment laid down in the 1980s and earlier. This is particularly the case in countries like Canada and the U.S. where requirements to address cumulative effects have become explicit.

Even protected areas are vulnerable to cumulative effects, whether from land-use activities beyond their boundaries or from internal development. Proclamation of the Canadian Environmental Assessment Act in 1995 brought formal obligations to consider cumulative effects. The first two reports published by Parks Canada in a series of "technical reports in ecosystem science" address the assessment of cumulative ecological effects in Canadian National Parks (Kalff 1995; Keith 1996). Keith (1996) addresses the "cumulative effects of development and land use at Prince Edward Island National Park," where natural resources (notably coastal sediment- and dune-systems) are threatened by the popularity of the park's beaches and the sustainability of the park ecosystem is at risk from cumulative impacts of visitor pressure. The report proposes a CEA framework based on recognition of the inherent limitations of project-EIA, and the need to expand the boundaries of impact assessment to "take account of spatial and temporal dynamics of environmental resources of concern and the anthropogenic activities influencing them" (Preston and Bedford 1988). The following conclusions are reached:

- Due to the spatial complexity of cumulative effects, an ecosystem approach must be adopted.
- Indicators of environmental health and ecosystem integrity must be identified.
- Past, present, and foreseeable future development activities must be considered.
- Ecosystem responses to previous and ongoing activities must be understood as well as data allows—lack of baseline data and historical monitoring hinders this process.
- Environmental attributes, existing development, and land use and societal goals should be used to define permissible levels of development activity.
- Ideally CEA should be conducted in relation to regional land use planning. (This may be complicated by political and jurisdictional issues).
- Further scientific investigation and monitoring is needed to increase understanding of ecosystem processes, to test the validity of assumptions about ecosystem responses to stress and to test the validity of mitigative strategies.
- Analytical tools such as GIS, aerial photography, and satellite imagery and computer modelling should be used to gain insights into system behavior and cumulative environmental change.

Important problems remain, notably the fact that there is an "incomplete knowledge base regarding the organization and behavior of ecosystems in response to cumulative effects" which can result in unanticipated problems (Keith 1996). While the concepts of carrying capacity and viability thresholds are generally accepted to be germane to assessing cumulative effects, they are not well understood. There is a general belief that "potential non-linear ecosystem responses to increasing cumulative impacts may lead to fundamental, irreversible changes once a threshold is reached beyond which the system can no longer recover from disturbance" (U.S. NRC 1986), but defining this threshold remains far from straightforward for most ecosystems. Clark (1994) stresses that there are still difficulties in determining the appropriate spatial and temporal bounds for cumulative effects assessment.

Integrated Assessment of Development and Resources

A number of recent papers have emphasized the need to consider development scenarios and natural resource inventories together and to take account of all past, present, and future threats with respect to the status of the resources affected (declining, stable, increasing). Sadler (1996) emphasizes that "more integrative ecosystem-based approaches, merging EIA and land use planning" are required, "particularly to address cumulative effects."

New approaches to sustainable resource management are needed to (Thompson, Treweek, and Thurling 1995):

- Measure the current state of the resource
- Define current uses and rates of use
- Define acceptable limits of use/carrying capacity
- Project future levels of consumption/use
- Define objective limits to growth based on "ecological capacity"
- Monitor the effects of resource consumption on resource availability
- Modify use if carrying capacity or thresholds of damage are exceeded.

Comprehensive assessment of natural resources for regional ecological planning is the way forward and SEA provides a possible framework. Thompson et al. (1995) explore the potential application of SEA to farming of Atlantic Salmon (*Salmo salar L.*) in Scotland, primarily as a means of dealing with serious cumulative impacts on benthic organisms, sea birds, and native populations of fish. EIA is currently failing to tackle the cumulative effects of (largely) uncontrolled proliferation of the industry in important coastal habitats. It is also failing to address the disturbance effects of operational activities on native wildlife (sea birds and seals), the knock-on effects of associated infrastructure development (particularly for access and transport), the excessive use of wild fish stocks to feed captive fish, the possible cumulative and synergistic effects of chemical releases, trans-boundary pollution effects, effects on genetic constitutions of wild salmon populations and effects on population dynamics, including disruptions to predator-prey relationships. A more strategic approach to assessment is clearly required.

Increased licensing for oil and gas exploration and production in U.K. waters in recent years, coupled with a move into ecologically sensitive inshore waters, has also been a cause of concern to nature conservationists. Again, licensing has continued, without any overall assessment of cumulative impact. Earlier this year (in response to pressure from NGOs (non-government offices) and other groups), the European Union ruled that the government must implement the 1985 EIA directive with regard to offshore oil and gas development (Green 1995). A consortium of wildlife conservation groups presented the government with a detailed proposal to reform the licensing process to take account of both the EIA directive and the Government's international commitments with regard to conservation of biological diversity.

The consortium called for a full SEA of the continental shelf to assess its biological resources and their sensitivity. The SEA would identify areas too important to develop as well as areas where information is inadequate to estimate vulnerability with confidence or where technology is inadequate for safe and sensitive development and the precautionary principle should apply.

Strategic Ecological Assessment in Practice

Examples of the use of strategic ecological assessment are emerging as SEA legislation strengthens. Examples where ecological considerations have been addressed through SEA are listed in Therivel and Thomspon (1996) and include:

- SEA of petroleum activities in the Barents Sea, Norway: predicted impacts of oil spills on seabirds and fish eggs and larvae (United Nations Economic Commission for Europe 1992)
- SEA of German windfarms: ecological constraint mapping using endangered bird species and valuable biotopes as indicators (Kleinschmidt 1994)
- SEA of Firth of Forth transport strategy (Scotland): planning to minimize impacts of new road works on natural features of significance for biodiversity, especially loss, disturbance, or fragmentation of areas important for nature conservation (Scottish Office 1994)
- Response to EC's 1993 SEA for the Trans-European Rail Network by Birdlife International and the World Conservation Monitoring Centre: planning to maintain or restore habitats and species of wildlife at favorable conservation status with respect to development (Bina, Briggs, and Bunting 1995).

Information Technology

New developments in information technology should continue to assist data collation and management for large-scale inventory and monitoring. The use of geographic information systems (GIS) for ecological impact assessment is increasing. Eedy (1995) reiterates the utility of GIS for:

- Management of large data sets
- Data overlay and analysis of development and natural resource patterns
- Trends analysis
- Data set for mathematical impact models
- Habitat analysis.

"As the demand for spatial information grows there is an ever-increasing synergy between remote sensing and GIS." Wilkinson (1996) gives a comprehensive review of recent developments in these areas. Veitch, Fuller, and Treweek. (1995) describe the use of a national land cover map derived from satellite imagery for analyzing landscape-scale impacts, including habitat fragmentation. The use of remotely sensed data and GIS for assessing the spatial impacts of new road development on wildlife habitat is described by Treweek and Veitch (1995) and Treweek and Veitch (in press). Carey and Brown (1995) used remotely-sensed land cover information, GIS and data on species-distribution and climate to model the impacts of a hypothetical climate-change on the national distribution of a rare orchid species. These approaches demonstrate the value of reliable national data for ecological planning and emphasize the need for strategic planning frameworks which permit their implementation.

Mercer (1995) reminds us that "the maxim garbage in, garbage out applies only too well to the computer-related forms of environmental assessment." The quality of ecological survey and monitoring data therefore remains paramount.

Surveys: Timing

It goes without saying that sensitive ecological resources and periods should be avoided when planning either development activity or ecological surveys. However, reviews of ESs in the U.K. indicate how frequently field surveys continue to be carried out at inappropriate times (Thompson 1995). The "Guidelines for baseline ecological assessment" therefore correctly emphasize the "importance of carrying out field surveys for different species at an appropriate time of year" (IEA 1995).

Progress with Ecological Monitoring

The need for more ecological monitoring remains imperative, primarily to strengthen the ecological knowledge base and to enhance the robustness of ecological predictions. The uncertainty that surrounds the majority of ecological predictions is exacerbated by the lack of long-term data from coherent monitoring programs. There is not enough investment in longer-term ecological studies. Clark (1994) rightly emphasizes the need for "access to a national environmental baseline database." It is encouraging that the new Canadian Environmental Assessment Act contains specific provisions for carrying out follow-up and monitoring (CEAE 1996). However, integrated, comprehensive national monitoring of ecosystems and their biological diversity is far from straight forward. Briggs (1995) gives examples to illustrate the prevalence of errors and inconsistencies in environmental statistics used to guide environmental management and examines the implications of this for policy, monitoring and research. Articles by Barr (1994) and Stott (1994) summarize results of a major program of land-use monitoring in Britain carried out in 1990 and outline some of the issues and problems involved in organizing comprehensive national monitoring programs. The program was based on stratified random sampling in the field and remotely sensed land cover estimates. A repeat survey is planned for the year 2000 to build on the 1990 baseline. The sampling design used to monitor the status and long-term trends in extent and distribution of wetlands in the U.S. is summarized in a paper by Novitzki (1995) on the EMAP Wetlands Program. A key problem is the identification of suitable indicators for different wetland types, not to mention the sheer amount of fieldwork required to visit and survey such a huge number of sites.

Clark (1994) suggested that "the utility of a national environmental baseline database would be multiplied if agencies conducting impact analyses agreed to collect by ecological region, store these data based on common protocols and share access to environmental data." A nice idea!

Recommendations

Formal Requirements for Monitoring

Without monitoring, the ecological basis for impact prediction will remain limited. Monitoring is also required for evaluating mitigation success and is an essential part of any commitment to the conservation of biological diversity.

Strategic Ecological Assessment

More strategic approaches to ecological assessment are essential to ensure that cumulative, delayed, trans-boundary and indirect effects can be taken into account. The potential role of ecological impact assessment in implementing global agreements on sustainable development and the conservation of biodiversity demands concerted efforts to ensure that the frame of analysis is adjusted to take account of both administrative and ecosystem limits whether at local or global levels.

Investment in Data

Data on the distributions of habitats and species are the bedrock of ecological assessment. Additional investment in national datasets is required so that we can estimate the status of our biological resources with confidence. More consideration should be given to data applications, however, so that limited resources are channeled into monitoring attributes with the greatest predictive value.

Research on Processes and Responses

Investment in research on ecological processes and impact-responses is still needed. Predicting the effects of habitat loss, for example, requires knowledge of the population processes which drive responses to mortality or displacement of the individuals associated with that habitat (Treweek 1996). Papers by Reijnen and Foppen (1994), Foppen and Reijnen (1994) and Reijnen et al. (1995) which explore the effects of roads and their traffic on breeding bird populations in woodland in the Netherlands are examples of the type of study required.

Research on Genetic Diversity

Knowledge of the relationship between genetic diversity and the viability of populations is very limited, making it difficult to estimate the real implications of habitat fragmentation and isolation (Treweek 1996).

Avoidance of Damage at Source

Avoidance is always the best form of mitigation. Early consideration of ecological constraints reduces the need for mitigation later on.

Acknowledgment of Limitations

All predictive statements should be accompanied by confidence limits. This is particularly important for ecological risk assessment. While current U.S. CEQ regulations go into some detail about how risks should be referenced in relation to incomplete or unavailable information (Canter 1993), the latest draft European Directive on SEA appears to have dropped any requirement to quantify levels of uncertainty (Therivel and

Thompson 1996).

Getting Off the Fence

Finally, in debating "what ecology can do for environmental management," Shrader-Frechette and McCoy (1994) advocate a pragmatic approach, suggesting that ecology is more likely to be effective in guiding conservation policy if it is based on a "logic of case studies" rather than the traditional "logic of confirmation". Incomplete knowledge does not excuse inactivity. "Whether ecological problems are harder than those of other sciences or not, someone must address them" (Peters 1991).

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Environmental Justice Impact Assessment Key Components and Emerging Issues

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Abstract

Environmental justice calls for fair treatment of all people such that no one group bears a disproportionate share of adverse human health or environmental impacts. Through implementation of Executive Order 12898, Federal agencies are required to address environmental justice as part of their National Environmental Policy Act (NEPA) planning and decision-making process. Because environmental justice issues are only just beginning to surface in litigation, case history is not yet available to help define the scope of an environmental justice impact assessment. However, Federal draft guidance has been issued which generally recommends the inclusion of three key components in a NEPA environmental justice analysis: demographic assessment, impact assessment, and community involvement.

Key Words: community involvement, demographics, disproportionately high and adverse impacts, environmental justice, geographic information system (GIS), low-income community, minority community, National Environmental Policy Act (NEPA)

The Role for Environmental Justice Analysis in Our Existing Environmental Framework

Environmental Justice is defined by the U.S. Environmental Protection Agency (EPA) as “fair treatment” such that no group of people bears a disproportionate share of human health or environmental impacts (U.S. EPA 1995a, 1995b). For example, environmental justice seeks to prevent an agency from locating several pollution sources in a community that is predominantly low-income or minority. Environmental justice rose from grassroots concerns and has quickly become an issue of national importance. On February 11, 1994, President Clinton issued Executive Order 12898, “Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations.” In the order, President Clinton directed federal agencies to make environmental justice part of their mission and to identify and address disproportionately high and adverse human health or environmental effects of their programs, policies, and activities on minority populations and low-income populations (White House 1994a). In a Memorandum accompanying the Executive Order, President Clinton further directed agencies to incorporate environmental justice into their existing NEPA process and called for enhanced community involvement to address environmental justice issues (White House 1994b).

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The President's Council on Environmental Quality (CEQ), in consultation with other agencies, issued draft guidance to help agencies meet the Presidential environmental justice objectives (CEQ 1996). The U.S. Environmental Protection Agency (EPA) also published draft guidance designed to implement environmental justice goals into its own NEPA process (U.S. EPA 1996a). This paper incorporates some of the CEQ and EPA approaches, as well as approaches applied by the U.S. Department of Energy (DOE) integrating environmental justice in its NEPA process.

A NEPA environmental justice analysis should encompass three primary components: demographic assessment, impact assessment, and community involvement. Demographics of the population must be determined, specifically focusing on minority and low-income communities. Impacts from the proposed action and alternatives must be assessed and viewed in conjunction with the demographic data to determine the presence or absence of disproportionately high and adverse impacts on the identified minority or low-income communities. Where impacts are identified, mitigation measures should be developed to eliminate or reduce the potential impact. Heightened community involvement must exist throughout the process with heightened awareness and involvement of the potentially affected minority and low-income communities.

Environmental justice issues are becoming more prominent in the nation's legal system. An initial environmental-racism lawsuit was filed in Houston in 1979 by residents who wanted to block the siting of a new landfill. The residents claimed discrimination because the city and the landfill contractor proposed to site the new landfill in a predominantly African-American community (Jaffe 1996). Similar lawsuits have been filed, but did not reach the desired outcome in the viewpoint of the plaintiff. However, such lawsuits help define the problem, increase awareness, and begin the process of achieving solutions. This paper also examines some of the emerging issues with environmental justice lawsuits and discusses how these legal actions may influence future environmental justice guidance.

Components of an Environmental Justice Assessment

An environmental justice assessment is built around a framework of three primary components: demographic assessment, impact assessment, and community involvement. The first two components (demographic assessment and impact assessment) are interdependent; one requires the other. The third component (community involvement) is interwoven throughout and is perhaps the most important aspect of the assessment process.

Demographic Assessment

One component of a NEPA environmental justice assessment is the analysis of population demographics. A demographic assessment includes identification of minority and low-income communities. The three terms *minority*, *low-income*, and *community* are discussed below.

Minority

In an environmental justice analysis, *minority* includes individuals listed by the Office of Management and Budget Directive Number 15 as Black/African-American, Hispanic, Asian and Pacific Islander, American Indian, Eskimo, Aleut, and other nonwhite persons (Bureau of the Census 1991d; U.S. EPA 1994) based on self-reported status as recorded in the Census. Data on minority populations are available through the Census of Population and Housing in a processed data set, Summary Tape File (STF)-3A (Bureau of the Census 1991a, 1991b). STF-3A files contain sample data (as opposed to actual population counts) weighted to represent the total population and include data on income and other items. Data on race and Hispanic origin are available in STF-1A files, which contain data for a complete population count rather than summary data. Because the STF-3A files contain data summaries and not actual population counts, the data may or may not accurately portray actual site conditions, again underscoring the need for heightened community involvement to verify existing conditions. Analysts should also use caution to avoid double-counting persons who may be of Hispanic origin. Because the designation "Hispanic" is considered an origin rather than a race, analysts should organize data to include "non-Hispanic" categories (for example, non-Hispanic African-American).

Low-Income

Data on low-income populations are also available using Census data. The Current Population Reports, Series P-60 on Income and Poverty, provide current projections of minority populations based on the Consumer Price Index. Summary poverty tables are provided in the STF-3A files. In selecting a threshold level to define "low-income," analysts should avoid use of a single income level. For example, rather than selecting a single baseline, low-income threshold level, apply different poverty thresholds for different sized households. Poverty data for households, families, and persons for each county in every state are provided in Table 149 in the Census data set "Social and Economic Characteristics."

CEQ suggests two other sources of data to identify low-income populations: (a) the Department of Health and Human Services (HHS) poverty guidelines and (b) the Department of Housing and Urban Development (HUD) statutory definition for "very low-income." HHS publishes an annual update of its Poverty Guidelines in the *Federal Register* [60 F.R. 7772] (HHS 1995). HUD provides a statutory definition of "very low-income" in section 3(b)(2) of the Housing Act of 1937 (HUD 1937). HUD defines poverty on the basis of the median family income for an area (HUD 1974). A good practice is to apply a definition that most accurately reflects the relative cost of living in the area under consideration.

Community

The EPA calls for "judgment and sensitivity" in defining affected communities. While a numeric measure of greater than 50 % affected minority or low-income population in an area is one definition of a "community," the EPA is careful to advise selection of geographic areas that do not "artificially dilute or inflate" the affected population (U.S. EPA 1996a). Commonly used geographic areas include political boundaries such as Census Blocks and Census Tracts as defined by the U.S. Bureau of the Census. For example, data aggregated at a larger geographic scale (such as Census Tracts) may be appropriate for actions that may have widespread impacts. However, if analysis is needed on a more local scale, other data sets (such as Census Blocks) may be more appropriate. In either case, analysts should further examine the population profile of the defined community to identify the existence of any localized concentrations of minority communities or low-income communities that may or may not be apparent by examining a larger data set.

When defining low-income communities or minority communities, analysts should consider three factors as discussed below.

- *Common Conditions*. The EPA guidance cautions that a "community" may or may not reside in the same contiguous geographic area but may include people who experience common conditions, for example migrant workers (U.S. EPA 1996a). When defining communities, analysts should look for such conditions through field verification and heightened public involvement.
- *Population Profile*. Both CEQ and EPA advise analysts to go beyond the surface

of the data and look into the population profile for any pockets of minority communities or low-income communities that could be affected. Parameters such as age, sex, and population density should be examined. This approach will help identify any subgroups that may be more sensitive to the potential impacts than the remainder of the population. Such an examination of the population profile would also include looking for any people who may have certain dietary habits (such as consumption of a particular resource) or communities based on subsistence living (such as subsistence fishing, hunting, or farming). Sensitivities could also include cultural factors. For example, Native American communities may have cultural and/or sacred sites that may be affected even if people do not live on the site (environmental impacts to a sacred site could cause social impacts to a tribe). Consultation with Native American communities should be conducted on a formal government-to-government basis as established through U.S. Governmental and tribal agreements.

- *Potential Impacts.* In defining a "community," CEQ suggests a geographic scale that is "coextensive with [the same as] the potential impact area" (CEQ 1996). Analysts should therefore have knowledge of the potential impacts from a proposed action and alternatives, and an understanding of potential exposure pathways in order to best determine the geographic area for which population demographics are needed. Additional demographic assessment may then be required based on the impact data. This process becomes an iterative process; both components (demographic data and impact data) are interrelated and necessary for a complete assessment.

Impact Assessment

A second component of a NEPA environmental justice analysis is impact assessment. Because the Executive Order calls for an examination of disproportionately high and adverse *effects*, clear cause-effect relationships must be established among actions, impacts, and the resultant effects. As directed by the Presidential Memorandum, effects must be examined in three categories: human health effects, environmental effects, and economic/social effects. Two broad types of effects must be analyzed: disproportionately high and adverse effects, and multiple and cumulative effects. Effects should be further considered under the projected normal facility operations as well as under accident scenarios associated with the proposed action and alternatives. Where effects are identified, mitigation measures must be developed.

Human Health, Environmental, and Socioeconomic Effects

An environmental justice assessment integrates social, human health, and environmental impacts. Integrated social impact assessment involves knowing who is affected, what will happen to those affected, what will change, and how the actions will affect the stability of social systems. Social impact assessment examines factors such as conflicts with traditions, customs, religious practices, or Native American sovereignty issues; degradation of the aesthetic values; community disruption or segmenting; and economic change (changes in availability of housing, changes to property values, and/or changes to the tax base). Impacts to a site might occur even if people do not live or work on that site. For example, a Native American tribe may experience adverse social effects if a sacred site is subjected to adverse environmental effects. The EPA guidance provides further discussion on assessing social impacts (U.S. EPA 1996a).

Disproportionately High and Adverse Effects

When considering the distribution and severity of effects, analysts should consider three factors:

- Whether the impact would be above generally-accepted norms
- Whether the impact to the minority or low-income population appreciably exceeds (or is likely to appreciably exceed) impacts on the general population (or other appropriate comparison group)
- Whether the community is already affected by cumulative or multiple adverse exposures from other environmental hazards.

To determine whether effects are "disproportionately" distributed, analysts must use judgment and sensitivity based on the above definition. Analysts should apply some level of comparative analysis among the populations to determine if any communities or other groups of people would experience a greater share of the impacts. One approach is to determine the proportion of impact that would be experienced by an "average" resident in a reference population group compared with the impacts which would be experienced by a member of the affected minority or low-income community in the study group.

In the determination of the distribution of the effects, EPA reminds analysts to understand the demographics of the communities and how the lives and livelihoods of the members of these communities may be impacted by the proposed action. As previously discussed, minority and low-income communities may be concentrated in small pockets within the larger geographical study area. Furthermore, "communities" may not always be geographically contiguous. Therefore, broad analysis of impact distribution in the study area may not be adequate to analyze impacts which may be experienced by an individual community. Heightened community involvement should again be applied to ensure an appropriate level of analysis.

Multiple and Cumulative Effects

NEPA requires examination of direct, indirect, and cumulative effects. In an environmental justice context, special emphasis is placed on effects from multiple and cumulative exposures (exposures from multiple pollutants in one or more locations through various pathways over a period of time). As part of the definition of environmental justice, EPA notes that "No racial, ethnic or socioeconomic group should bear a disproportionate share of the negative environmental consequences *resulting from the operation of industrial, municipal, and commercial enterprises*..." (U.S. EPA 1994) [emphasis added]. To meet this definition, the environmental justice impact assessment should closely tie to the NEPA cumulative impact assessment of other past, present, and reasonably foreseeable future actions (both federal *and* non-federal) in the affected environment.

Minority and low-income populations are often located in areas that may already suffer from previous environmental degradation. Analysts should consider factors such as proximity to other emission sources, other environmental contamination, and increased susceptibility to health effects due to existing pollution (U.S. EPA 1996a). Because of the difficulty in identifying or projecting multiple and cumulative effects, analysis should be thoroughly familiar with the potentially affected communities. Heightened public involvement will help identify community concerns and issues that could lead to multiple and cumulative impacts.

The EPA guidance points to several federally-maintained databases which support analysis of multiple and cumulative impacts. Such databases include the Permit Compliance System for National Pollutant Discharge Elimination System releases; the Aerometric Information Retrieval System for ambient air quality data on the criteria pollutants; the Biennial Reporting System for waste generation from facilities regulated under the Resource Conservation and Recovery Act; the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Information System, which provides site data on both National Priority List (NPL) sites and non-NPL sites; and the

Toxic Release Inventory (TRI) System which contains data submitted to EPA by regulated facilities concerning chemicals and chemical categories listed by EPA under Section 313 of the Emergency Planning and Community Right-to-Know Act (EPA 1996a).

The HHS Public Health Administration maintains the Hazardous Substance Release/ Health Effects Database (HazDat) database which provides access to information on the release of hazardous substances from CERCLA sites and the human health effects related to those hazardous substances.

The National Institutes of Health provides access to the National Library of Medicine Toxicology Data Network (TOXNET®) which provides access to the Toxic Chemical Release Inventory (TRI), the Hazardous Substances Data Bank (HSDB®), the Integrated Risk Information System, the Registry of Toxic Effects of Chemical Substances (RTECS®), and the Toxic Chemical Release Inventory Facts (TRIFACTS) databases[2].

Normal Operations and Accident Scenarios

The previous discussion outlined the categories of effects (human health, environmental, and social effects) and the types of effects (disproportionate, multiple, and cumulative effects) considered in an environmental justice analysis. NEPA analyses generally consider this complete spectrum of effects, but usually only under normal operations associated with a proposed action or alternative. Analysis of normal operations can be directly applied to an environmental justice assessment. For example, the EPA has demonstrated effective use of a geographic information system (GIS) to assess potential disproportionate impacts to communities from normal or routine facility operations (U.S. EPA 1995). A new approach is to go beyond assessment of normal operations and include an examination of potential *accidents* associated with a proposed action or alternative (Wilkinson et al. 1996). This approach models a bounding case accident scenario and analyzes the potential effects that could result from that accident. Those effects are then graphically integrated and displayed with mapped demographic data using a GIS. Potential impacts from accident scenarios should be considered as another measure of the distribution of impacts in an environmental justice assessment.

Avoiding and Reducing Impacts through Mitigation and Alternatives

After examining the complete range of potential impacts, mitigation measures must be developed to address any significant and adverse environmental effects (either actual effects or perceived effects) on minority and low-income communities. If impacts are found to be distributed disproportionately, the goal is not to engage in an impact-shuffling “shell game” among communities but to design mitigation measures or new alternatives to avoid or reduce the impacts. EPA clarifies that the goal “is not to distribute the impacts proportionately or divert them to a non-minority or higher-income community.” When impacts have been identified, the goal is to design alternatives and mitigation strategies that meet agency and program goals and avoid or reduce the environmental, socioeconomic, human health, and ecological effects associated with the proposed action (U.S. EPA 1996a). Community involvement should be used to develop these alternatives and mitigation measures.

Integrating Impact and Demographic Data

Thus far, two key components of an environmental justice assessment have been discussed: demographic assessment and impact assessment. The next step integrates these

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[2]Similar data are available through EPA’s Envirofacts Internet homepage at http://www.epa.gov/enviro/htm.

two data sets in a single display. An especially effective tool for this integration is a geographic information system (GIS).

EPA uses a GIS-related system called LandView II. This system displays EPA-regulated sites, demographic and economic information from the 1990 Census, and key geographic features. However, LandView II cannot accept multiple data overlays.

In conjunction with the U.S. Geological Survey, the Bureau of the Census has developed the Topologically Integrated Geographic Encoding and Referencing (TIGER) System of maps known as “TIGER files.” The TIGER system automates the mapping and related geographic activities to support the Census. The TIGER files can be linked to the Census STF-3A files to produce a map that contains a spatial distribution of the population data (Bureau of the Census 1990, 1991c). TIGER files can be imported into a commercial GIS to accept additional data overlays.

In addition to these systems, several commercially available GISs could be used. The goal is to provide a graphical representation of the potential impacts of an action (under both normal operations and accident scenarios) with mapped demographic data. Such an approach provides an “especially effective” visualization of the distribution of impacts (CEQ 1996) and is useful for both decision makers and the public.

Community Involvement

A third component of an environmental justice assessment is heightened community involvement. The need for heightened community involvement has been emphasized throughout this paper in the identification of potentially affected communities, the identification of potential impacts, the development of mitigation measures, and the integration of impact and demographic data. Heightened community involvement is perhaps the single most important factor in achieving the Presidential goals for environmental justice. Although NEPA provides regulatory opportunities for public participation, the Executive Order and the accompanying Presidential Memorandum on environmental justice heighten the public participation requirements. With this increased emphasis to involve affected communities, the public participation process should be given increased forethought and planning. Heightened public involvement should be prevalent throughout the NEPA process from before scoping until after the decision. Federal decision makers and analysts should talk to key leaders of potentially affected communities to learn how to effectively involve the community in the NEPA scoping process.

EPA identifies several opportunities for heightened public involvement as follows: represent various stakeholder interests; overcome barriers such as language, literacy, cultural, and technical jargon; and regionalize materials to ensure cultural sensitivity, understandability, and relevance. Analysts should be sensitive to and respectful of race, ethnicity, gender, language, and culture. Sensitivity includes translating documents and hearings for people for whom English is not a primary language, and ensuring that documents and hearings are understandable and accessible. Another source of public involvement and general information is available through the World Wide Web (WWW) on the Internet at the address: *http://www.econet.apc.org/envjustice/*. This EcoNet EcoJustice Network provides current information on environmental justice issues, organizations, and publications. This network provides links to related home pages and other information sources such as GIS maps and mapping resources (Diaz, Rivera, and MacLean 1996).

Emerging Issues in Environmental Justice: Litigation and Federal Enforcement

Because environmental justice is a relatively recent legal issue, the justice system is only beginning to refine and hone the legal connotations of environmental justice. Although dozens of environmental racism lawsuits have been filed around the country, none have been completely successful (from the plaintiff's point of view). However, recent developments may change this track record.

A group of residents in Chester, Pennsylvania filed suit in a federal district court to argue that the State of Pennsylvania violated their civil rights. The suit accuses the state environmental agency of discrimination under the Civil Rights Act for issuing permits which would concentrate waste processing facilities in a primarily African-American neighborhood. Although a growing number of community groups have claimed discrimination in environmental lawsuits, the Chester case is one of only a few instances in which a state has been sued under the federal Civil Rights Act by plaintiffs who accuse the state of discrimination using the environmental permitting process. Previous lawsuits have focused on technical or procedural issues in which communities had to prove either adverse impact on their health or welfare, or intentional violation of their rights — both of which are difficult to prove in court (Jaffe 1996). Using this Civil Rights Act tactic, the plaintiffs are *not* required to show *intent*, but merely the *effect* of discrimination. The Chester lawsuit makes no claims of adverse health effects by residents living near the plants. Instead, the lawsuit claims discrimination because the Pennsylvania Department of Environmental Protection granted an operating permit to a fifth waste treatment plant in one of Chester's primarily black neighborhoods (Janofsky 1996).

In Pensacola, Fla., another type of environmental justice issue is making history. A citizen's group has complained of pollution-induced cancer, respiratory problems, and skin rashes from a dioxin-contaminated area. While dioxin contamination and community relocation issues have been seen before in other parts of the country, the Pensacola case is the first EPA pilot project demonstrating President Clinton's commitment to environmental justice by improving community relocation decisions (Environmental News Daily 1996).

Environmental justice issues have also been cited in other federal environmental legal actions where environmental justice is not the primary focus of the complaint. In a landmark settlement of a Clean Air Act suit, the Copper Range Company agreed to curb mercury, lead, and cadmium output from its smelting plant in White Pine, Michigan, and to pay $4.8 million for civil penalties and environmental projects. Because the Copper Range Company is the largest emitter of mercury in the Upper Great Lakes area, the case also included environmental justice issues due to excessive levels of mercury in fish taken for subsistence purposes by local Native Americans. The settlement included relief for the local Native Americans whose blood contained elevated levels of mercury (U.S. EPA 1996b).

The EPA has also created an Environmental Justice Program within the Enforcement, Compliance, and Environmental Justice Office. This program office reviews federally-issued environmental permits and federal environmental inspections for potential environmental justice issues. The EPA has initiated 320 investigations which target industries that have repeatedly committed environmental crimes in minority or low-income communities. The EPA has also prepared environmental justice profiles of twenty-five federal installations across the country to serve as models for how agencies should consider environmental justice in their planning processes (U.S. EPA 1996b).

Examples such as the Chester lawsuit, the EPA pilot project in Pensacola, Fla., the citation of environmental justice issues in other environmental cases, and increased EPA enforcement actions will help define how agencies address and resolve environmental justice issues and will help to refine the current draft federal environmental justice guidance.

Recommendations

A primary goal of President Clinton's Executive Order on Environmental Justice is the desire for *all* communities and persons to live in a safe and healthful environment. As a required component of the NEPA process, federal agencies have met with varying degrees of success incorporating environmental justice into their NEPA processes; some agency NEPA documents provide more detailed environmental justice analysis than others and some agency NEPA documents have not yet addressed environmental justice issues. At a minimum, environmental justice assessments should incorporate three key components: demographic analysis, impact assessment, and community involvement. This paper has presented recommended guidelines for conducting these analyses.

Although draft federal environmental justice guidance is available, there is no recipe for a complete environmental justice assessment. Of the three primary ingredients, heightened public involvement may be the most important to meet the goals of environmental justice. While draft federal guidance is available, emerging legal challenges and issues will further refine the direction of future environmental justice guidance. In the interim, application of the three primary steps discussed in this paper will further the Presidential goals and objectives for environmental justice and guide agencies in the right direction for considering environmental justice as part of their NEPA planning and decision-making process.

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Selecting Computer Models and Input Parameters for Analysis of Environmental Impacts

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Abstract

Computer models are powerful tools for analyzing complex impacts on air quality, groundwater quality, human health, and ecological resources. This paper examines some of the challenges involved in using computer models for environmental impact analysis. This paper presents approaches for helping technical specialists and managers to work together and ensure that the modeling process is effective.

Key Words: computer model, input parameters, accident analysis, air dispersion, source terms

Introduction

Increasing numbers of computer models are used for analyzing environmental impacts. These models are excellent tools for environmental impact analysis, as long as they are used with care. This paper examines some of the challenges involved in using computer models for environmental impact analysis. The paper addresses these challenges from the perspective of the manager who is responsible for conducting the impact analysis but who is not a computer modeling specialist.

There are computer models for almost every discipline in environmental impact analysis. Computer programs can analyze routine air emissions, accidental air dispersion of radionuclides or chemicals, groundwater transport, transportation, ecological resources, and socioeconomics, as well as other disciplines. The advantage of using computer models is that extensive environmental data can be managed and complex calculations can be performed quickly to assess existing conditions and to project impacts under different alternatives. This has become necessary as the public has become more sophisticated about environmental impacts and more complex analyses are conducted to address their concerns. For example, the Department of Energy (DOE) requires that Environmental Assessments and Impact Statements provide estimates of the potential public health effects from radiological exposure due to normal operations and potential accidents (DOE 1993). Computer models are typically used to calculate the air dispersion of radionuclides under varying meteorological conditions and to estimate the collective public dose and the dose to the maximally exposed individual member of the public.

Impact analysis can be greatly enhanced by using computer models. However, there are many potential pitfalls in selecting models and input parameters for an impact analysis. It is extremely important that the computer modeling be carefully managed. Unfortunately, the impact analysis manager tends to retreat from the technical questions related to computer models and defers to the specialist. This paper discusses the reasons

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why an impact analysis manager should be more involved in the selection of computer models and input parameters and offers suggestions for how to ensure quality in the modeling process.

Multiplicity of Models

Typically, there are several computer models available within each of the various impact analysis areas. The multiplicity of models is illustrated by an informal review of fourteen Environmental Impact Statements (EIS) prepared recently by DOE.[2] A total of forty-eight different computer models was used in those fourteen EISs. The number of models used in the different disciplines provides an indication of the great diversity of models available, as well as the challenges involved in selecting these models. For those who are not immersed in computer models, the names of the codes can seem like alphabet soup, since they tend to be acronyms. The effect of discussing the types of models used in environmental impact analyses can result in MEGO, the acronym for "My Eyes Glaze Over." Nevertheless, a few examples indicate the diversity of models available.

In five of the fourteen EISs prepared by DOE, surface water and ground water impacts were analyzed with computer models. Seven water quality models were used: LADTAP XL, UNSAT-H, MINTEQ, MSTS, HST3D, MODFLO, and MT3D. Each model has distinctly different capabilities, and some of the models were used in conjunction with other models. For example, MODFLO is a model developed by the U.S. Geological Survey to simulate two- and three-dimensional groundwater flow in aquifer systems, and MT3D is a three-dimensional contaminant transport model that can be used in conjunction with MODFLO.

To assess the impacts of facility accidents, the fourteen EISs used a total of thirteen computer models. Six of the EISs used the MELCOR Accident Consequence Code System (MACCS), which was developed for the Nuclear Regulatory Commission to calculate the consequences of accidental radioactive releases. Two of the fourteen EISs used CHEMPLUS, a chemical dispersion code that predicts health impacts from fire and explosions. Other accident analysis models used included AXAIR89Q, GENII, DEGADIS, ERAD, ISC, CHARM, LAP, MEPAS, EPI, ALOHA, and SLAB.

The point of these examples is that there is a multiplicity of models available and choices have to be made about which model to use for a particular impact analysis. Why should one water quality model be chosen rather than another? Or one accident analysis model over another?

Model Characteristics

Each model has certain characteristics that make it more or less useful in a particular situation. One key characteristic is whether the model is available in the public domain. The most credible model to use will typically be a model that has been recommended by a public agency. Some models are recommended by the U.S. Environmental Protection Agency (EPA) for compliance with environmental permitting requirements. For example, CAP-88 is the EPA-recommended computer model for analyzing radiological air releases and for dose/risk assessment, as required by the Clean Air Act National Emission Standards for Hazardous Air Pollutants. Five of the fourteen EISs prepared by DOE used

[2] This review of computer models used in Department of Energy EISs was conducted by Lawrence Livermore National Laboratory for the Office of Defense Programs National Environmental Policy Act Compliance Officer. The review was informal and has not been published.

CAP-88 for analysis of radiological air releases during normal facility operations. Six of the fourteen EISs used other models for radiological air releases and dose assessment. Regardless of how good these models are, they will not have the same credibility as the EPA-recommended computer model. If it is not possible to use a computer model recommended by a public agency for some reason, the model selected should be able to meet the following three criteria. First, the model should have been validated by independent peer review. Second, the model should be well documented. Third, the model should be available to the public. If a model cannot meet these criteria, it probably should not be used for environmental impact analysis, unless there are extenuating circumstances.

Another consideration is that models have varying requirements for data. Models that require relatively less data rely more heavily on conservative assumptions. Whereas conservative assumptions are more defensible to the public, the outputs may be unrealistic and may cause unnecessary concern. For example, if there is no data available on how much hazardous or radioactive material would be released in a particular transportation accident scenario, the conservative assumption would be that 100% of the material is released. If there were data available indicating that only 50% of the material would be released in that type of accident, it would be preferable to use that data for the modeling process rather than the conservative assumption of 100% release. From this example, it should be clear that data and assumptions may make a great difference in an analysis. Thus, the model's requirements for data should be carefully considered.

Selecting Models

Ideally, the technical specialist would review the different computer models available, consider the characteristics of the various models, and select the model best suited for the analysis. Unfortunately, the selection of computer models is rarely an ideal process. The typical case is the discipline specialist selecting a model that he or she knows best. Since few managers are knowledgeable about all of the different models available in the various disciplines, it would be difficult for even the most conscientious manager to provide a meaningful review of the specialist's choice of models. The manager tends to defer to the specialist's selection of a model without getting a second opinion.

Even when a discipline specialist would prefer to select the model with great care, he or she may feel constrained by other factors. When funds and time are limited, as they almost always are, it may not seem practical to undertake a systematic review of models before selecting one for an analysis. Also, reviewing the full range of models available may seem like a pointless exercise if there is no staff qualified to run the different models. That is why people tend to pick the models which the existing staff can run. It takes time and money to consider the options before selecting a model and to train staff to run a model. If the specialist raises issues about selecting the right model or training the staff, the manager may not be willing to listen, or may even blame the specialist for raising these issues.

There is a great deal of risk in using a model that is poorly suited to the project. We all know that models can generate inaccurate results. When the wrong model is selected, the risk of inaccurate results is increased. If the inaccuracies are discovered by the technical staff, and additional model runs have to be conducted, schedule and budget problems may result. That would be the best case scenario. However, sometimes the technical staff does not find the flaws in the analysis before it is published. If the public reviewers find the flaws, the cost may be really high. Technical credibility can be very fragile in the environmental analysis process, especially when a controversial project is involved. If the problems are discovered by the public, the credibility of the entire impact analysis can be thrown into doubt. When that happens, the project itself is in great jeopardy. Putting some resources into the process of selecting the best model for the analysis is similar to buying insurance—it dramatically reduces the risks involved.

Selecting Input Parameters

Even if the best model for the job has been selected, the modeling process will not be effective unless the input parameters are also carefully selected. For example, the key input parameters in accident analyses are the “source terms,” which are the chemicals accidentally released to the air. In discussing source terms, Shinn states that “the best methods of source term estimations come from actual observations and experience” (this volume). Empirical data are the best input parameters for computer models.

When empirical data are used in a model, there should be careful checking to ensure that the data are correct. To illustrate the difficulties that can be caused by incorrect data, it is useful to consider the case of an accident consequence analysis for a uranium processing facility. An air dispersion model, such as MACCS (discussed above) would be used to estimate the radiological effects of a facility accident on the surrounding public. The modeling specialist would likely be very knowledgeable about MACCS and air dispersion of radionuclides. However, he or she may or may not be knowledgeable about uranium. One input parameter to the MACCS code would be the isotopic content of uranium 234. If the modeling specialist did not use the correct data for isotopic content, the results of the MACCS code runs would be inaccurate. Checking all empirical data with appropriate technical experts would avoid this problem, obviously. Unfortunately, that simple step is sometimes overlooked in the modeling process.

When empirical data are not available, assumptions have to be used as input parameters, and even more caution is advised. Assumptions should be the best judgment of an expert, not the best guess of someone without expertise in that area.

Managing the Modeling Process

To avoid problems with impact analysis modeling, a process is needed for managing the modeling. The process should include a review of the different models that could be used in each of the impact areas, such as routine air emissions, accidental air dispersion of radionuclides or chemicals, groundwater transport, transportation, ecological resources, and socioeconomics. The modeling specialist for each impact area should compare the different modeling options and address questions such as the following:

- What empirical data regarding environmental conditions are available as modeling inputs?
- What information is needed regarding the proposed activities and the alternatives?
- How does the available data match each model’s requirements for input parameters?
- What kinds of assumptions will need to be made if data are not available?
- Are there issues associated with use of that model, such as the need for staff training?

The review should summarize the advantages and disadvantages of each model and recommend model(s) for the analysis. The model review can be summarized in the methodology appendix of the impact analysis document.

A model review is provided in the accident analysis appendix of the EIS for Continued Operation of Lawrence Livermore National Laboratory and Sandia National

Laboratories, Livermore, Calif. (DOE 1992). The appendix compares three models that were considered for estimation of radiation doses: GENII, MACCS and ARAC (MATHEW/ADPIC). The Gaussian plume air dispersion in the GENII and MACCS models is compared to the particle-in-cell dispersion in the ARAC model. Various other characteristics of the models are also compared, including the exposure pathways; GENII calculates the air, ground, inhalation, ingestion, and surface water pathways, while MACCS and ARAC calculate all of those except surface water. In explaining why GENII was selected for the EIS accident analysis, the appendix discusses various technical issues and notes several additional factors: GENII is in the public domain; it has been used in other DOE impact analyses; and the code can be run on an IBM personal computer.

A manager who wants to be even more certain that the best models have been selected should have a peer review process for the model recommendations. The peer review team should be composed of persons with expertise in one or more of the following three areas: the proposed project, the impact disciplines, and modeling. In evaluating the models, the peer review team should carefully consider the status of the model in the public domain and the data requirements for the model. If the recommended model has not been endorsed by a public agency, special attention should be given as to why this model should be used. The team may also provide a review to verify the empirical data and assumptions used as input parameters in the modeling process.

Peer review teams have been used for several major DOE EISs recently. The peer review team for each EIS consisted of the DOE staff from Headquarters and the Field Offices as well as impact analysis specialists from the DOE National Laboratories. This peer review approach clearly minimized the problems associated with modeling during the EIS preparation process.

Recommendations

Computer modeling can be an effective tool for impact analysis when the models and input parameters are carefully selected. Managers should get more involved in the modeling process and ensure that the most appropriate model is selected for each impact analysis area. Modeling specialists should conduct a review of different models that could be used and recommend a model for specific reasons. Peer review of the model selection and input parameters is also recommended to ensure that computer modeling provides accurate results for the impact analysis.

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Source Term Estimation and Atmospheric Dispersion

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Abstract

The source terms chosen to estimate potential health risk in impact assessments are of equal importance to the selection of the model for atmospheric dispersion. Routine source terms are more than just stack emissions and include such things as operations emission factors, fugitive emissions, and more challenging source terms such as open detonation. Off-normal source terms need to be defined for the proposed operations in an assessment and include mechanical, fire, and natural hazard upset conditions.

Key Words: health risk assessments, emission factors, fugitive emissions, accident source terms, atmospheric dispersion

Importance of Atmospheric Source Terms

It has been said that an environmental assessment should be done before any investment is made in a rigorous health risk assessment (HRA). But in truth, no environmental assessment can be successful without at least a screening-level HRA. If any action is proposed that involves toxic materials handling, then it follows that there are potential risks of human exposure. So the analyst must begin with a screening-level HRA, and if the risks are trivial, then perhaps a rigorous HRA is unnecessary.

If the heart of an impact analysis is a health risk assessment, then the soul of the HRA is the estimation of the "source terms." This is especially true for scenarios of releases to the atmosphere. (In simplistic terms, the source term is the grams per second of chemical released to free air). For example, one may pick or choose between various atmospheric dispersion models based on arguments for required conservatism or precision, but the errors in source term selection always transfer directly into errors of exposure end points, whether concentration, dose, or dry deposition. Casual determination of a source term thus renders moot the argument of model selection. Model selection is not a trivial step, and requires an understanding of the needs as well as model capability (Meier, this volume).

Routine Atmospheric Release Source Terms

Routine releases are usually the more easily estimated source terms compared to off-normal releases from a proposed action. If the proposal is to build a facility, the tendency for the analyst is to think only in terms of point source releases, such as from a stack; however, operations source terms and fugitive emissions should also be considered.

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Operations source terms involving processes (i.e., industrial processes, chemical processes, or waste treatment processes) are calculated from an emission factor (grams of substance released per Kg of material processed) multiplied by the throughput, Kg of material processed per unit time. These emissions may or may not transfer to the atmosphere through a common stack. Calculation of emission factors has been done in the past for many kinds of operations and are compiled, for example in AP-42, (U.S. Environmental Protection Agency (EPA) 1988). Then, if the analyst can locate or calculate the emission factors, all that is needed to complete the source term is the knowledge of processing rates in the proposed actions. But there are other types of releases that occur on a continuous or frequent basis.

Fugitive emissions are those that potentially occur widespread over a facility. The analyst must deal with emissions such as from loading or unloading bulk material, for example spilled powder or suspended particulates. Other fugitive emissions may come from traffic on contaminated surfaces, leaky valves, open tanks, liquid filling operations that displace vapors, and many similar activities. Estimation methods for fugitive emissions and suggested mitigations for their control are reviewed by Kinsey and Cowherd (1992). A resource of information on leaky valves is from the petroleum industry estimated number and average annual emissions from valves on pipelines in refineries (U.S. EPA 1995). The analysts' estimates of these kinds of emissions should be weighted over the proposed lifetime of the facility.

Liquid filling ("stinging") operations can displace the container volume, and that is a straightforward source term estimation from the vapor pressure and temperature of the previous liquid in the container. Another challenge for the analyst is the source term estimation from routine uncontrolled combustion, and a good example is open burning/open detonation (OB/OD) of residual explosive. Debris from the decommission of weapons is commonly disposed by the OB/OD method, and permitted by local regulators as a safe and acceptable method. But the analyst likely does not have models for such an energetic release and so "cobbles up" a point source estimation that at best is an educated guess. The code HOTSPOT is a public domain method used (Homann 1994), but see Baskett and Cederwall (1991) for further guidance. In some cases, the explosive releases can be approximated as a two part source term, with an initial source term estimation from the explosions expressed as an area source, and the second part just dispersion from the area source. Such was the case of particle releases from training operations with U.S. Army smokes and obscurants that have a very predictable initial size (Shinn et al. 1987).

Stack or ground-level releases are straightforward for regulatory atmospheric dispersion codes. For example, the EPA supports ISC3 for an Industrial Source Complex, and DOE mandates CAP88 for routine radioactive releases from nuclear materials facilities. But the analyst must be careful about choosing the correct estimate of source abatement internal to the facility. If vapor scrubbing is proposed, for example, then the efficiency of the scrubber for all the possible vapor emissions must be calculated. For one vapor control option, granular activated charcoal, it must be realized that all volatile organics are not scrubbed equally (Yaws, Bu, and Nijhawan 1995). Also, in spite of the fact that high efficiency particulate filters (HEPA) are maintained at greater than 99.9% efficiency, the EPA allows only 99% credit as an operating rule.

The analyst must be fully aware that the regulatory atmospheric dispersion codes are gaussian plume calculations designed to be used for annually averaged releases and are only conservative if the proposed action does not plan high peak-to-mean, or acute releases. Some of the possible consequences of emissions are more than acute inhalation exposure. For example, air toxic, heavy-metal contamination or radio contamination could result in exposure via the ingestion pathway or via resuspension from the soil surface in a chronic inhalation exposure. In these examples, atmospheric deposition calculations are an important exposure endpoint from the initial source term considerations.

Off-Normal Atmospheric Source Terms

The proper impact assessment will consider all the potential releases due to accidents. Accident source terms are derived from identification of the material at risk (MAR). One way to quantify the source term is to then multiply the MAR by an atmospheric release fraction (ARF), by a release rate (RR), by a respirable fraction (RF), and by a leak path factor (LPF). Values of these factors have been gained from operational experience. A valuable handbook has been compiled by Jofu Mishima (Department of Energy (DOE) 1993). The ARF defines how much of the MAR is released by an accident, and values are usually given as both median and ninety-fifth percentiles. The RR is not always given in a handbook because it is usually process dependent. The RF is important if particles are released and some are of respirable size (less than ten micrometers aerodynamic diameter). In the case of a gas, RF = 1. The leakpath factor is used if the scenario calls for an accident producing rubble that may inhibit the release.

Hanna and Drivas (1989) compiled guidelines for vapor cloud source terms from chemical releases. They provide examples of releases of pure pressurized vapors (HF, NH_3, etc.), multi-component fluids (gasoline, unstabilized naptha), flashing liquids with and without aerosol formation, non-flashing liquids, and vapor release from pipelines. They also define a “Largest Practicable” release as one with some reasonable potential of occurrence, and a “Largest Potential” release that assumes catastrophic rupture of either the storage vessel or large diameter piping. In both of these cases examples are given of the size of the rupture, blowout, or failure that are very helpful to the analyst.

In many instances there are precedents available for dealing with the special case of off-normal releases. The best examples are the operations dealing with safe handling of hazardous materials. When there is a history of such operations, the standard operating procedures have been worked out with methodologies for estimation of accident consequences. For example, within the community of DOE facilities there has been compliance with methodologies in Safety Analysis Reports that estimate source terms for all manner of accidents such as pressurized gas releases, blowdown, fire, explosions, nuclear criticalities, etc., for each operation (usually building by building). The consequences of the accidents are keyed to Emergency Response Planning Guidelines, as interim standards for exposures to chemicals and other hazards. For the environmental impact analyst, these Safety Analysis Reports (or their counterparts in non-DOE facilities) are the best resource for atmospheric source terms. But the question arises, where does the analyst obtain the estimates of risk?

In fact, the high risk perceived by the public for very hazardous operations generates concern about the influence of natural hazards (extreme winds, earthquake, floods, etc.). While there are methods for estimation of risk due to accidental releases (a topic beyond the scope of this paper), the analyst should realize that the impact assessment must define a reasonable worst case and calculate the consequence regardless of the actual risk, because the public will demand to know what would be the result of a “disaster.” A classic case was the “all-fall-down-scenario” requested of an environmental impact assessment during public comment for a calculation of what would happen if all buildings in a facility should collapse at once even though the return period of a beyond-design-basis seismic event or Fujita-magnitude seven tornado would be several thousand years. The analyst must be prepared to at least rank all the possible accidents so that the more frequent-low consequence accidents stand out from the less frequent-high consequence events. From such a ranking should come a matrix of upset conditions due to mechanical, fire, and natural hazards, and a logical basis for qualitative limitations to the number of actual consequence calculations required.

Mechanical upsets would be such events as forklift operator error, failure of ventilation exhaust, falling containers, etc. Fire consequence should be estimated whenever fuel is present at the same location as hazardous material, such as at a loading dock. Natural hazards consequences should be estimated from scenarios such as building collapse. For many facilities, the return period of the catastrophic events "beyond design basis" seismic events, extreme winds (tornadoes, etc.), and floods have been tabulated (Kennedy et al. 1990).

Potential Improvements to the Source Term Estimation Problem

It is not yet fully realized by agencies such as DOE doing "safety analyses" of their operations that the results are also important to the environmental impact assessment process. There is some reluctance by those safety analysts to see their results viewed as reasonable worst case scenarios for bounding case analyses in impact assessments. In the future, these separate assessments will likely be integrated for the best quality and highest efficiency.

The best methods of source term estimations come from actual observations and experience. Such things as the fraction of spilled powder suspended, the emission factors in AP-42, and the definitions of Largest Potential and Largest Practicable release scenarios have come from experience. Models seldom help in these particular instances, because so many factors ("model parameters") have to be estimated. Experimental simulation of release scenarios and accidents will remain the best resource of source term estimations. But the costs of these experiments is high, and the funding lacks a primary sponsor. There is a continuing need to produce documents summarizing the priority of needs among source term analysts, and outlining experimental designs and objectives.

The next level of sophistication is the knowledge of uncertainty in assigning source term estimates. There is very sparse information on uncertainty in general, and the risk analyst using Monte Carlo methods would be greatly aided if percentile values could be obtained. More progress is needed on this problem to reduce the costs that over-conservatism produces in impact assessments.

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Framework for Assessing the Effects of Radioactive Materials Transportation

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Abstract

Radioactive materials transport may result in environmental effects during both incident-free and accident conditions. These effects may be caused by radiation exposure, pollutants, or physical trauma. Recent environmental impact analyses involving the transportation of radioactive materials are cited to provide examples of the types of activities which may be involved as well as the environmental effects which can be estimated.

Key Words: transportation risk analysis, radioactive materials transport, transportation impacts, impact assessment, environmental impacts, National Environmental Policy Act (NEPA)

Background

Thorough, consistent, and comprehensible transportation risk analyses in National Environmental Policy Act (NEPA) documents are essential, especially when transportation is a key element of a proposed action. Transportation of materials often brings a proposed action out of an isolated site into an otherwise unaffected community. These activities are easily overlooked when determining the scope of an environmental analysis. When transport is a major factor in a proposed action (e.g., transportation of materials for a large construction project), or of public concern (e.g., transportation of spent nuclear fuel), the environmental impacts of such transport should be analyzed. By examining the nature of the proposed action and alternatives, a determination may be made whether to describe the transportation impacts qualitatively or to analyze them quantitatively.

This article focuses on radioactive materials transportation, a primary activity that supports Department of Energy (DOE) missions. Transport of radioactive materials presents a number of issues which do not exist with the shipment of other materials, including other hazardous materials. Even in incident-free transportation, workers and members of the public may receive a radiation dose during movement and handling. In addition, the level of public concern about radioactive materials demands that analyses be comprehensive and include transportation impacts.

Recent Transportation Risk Analyses

Occasionally, transportation is the principal activity in a proposed action, such as when a large quantity of material is sold and must be moved from the seller to the buyer. In most cases, however, a proposed action is supported by transportation activities. Two

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NEPA documents involving transportation as secondary activities are used as examples: the *Environmental Assessment for the Proposed Interim Storage of Enriched Uranium Above the Maximum Historic Storage Level at the Y-12 Plant, Oak Ridge, Tennessee* (DOE 1994) and the *Final Environmental Impact Statement for Proposed Nuclear Weapons Nonproliferation Policy Concerning Foreign Research Reactor Spent Nuclear Fuel* (DOE 1996).

In the Y-12 Environmental Assessment (EA), DOE proposed to continue receipt, processing, and interim storage of enriched uranium in quantities that would exceed the historical maximum storage level. The proposed action involved the transport of highly enriched uranium by both Safe Secure Trailer (SST) and commercial trucks and the transport of low enriched uranium by commercial carrier. SSTs are robust vehicles operated by DOE which are accompanied by escort vehicles equipped with armed couriers and have other communications and security equipment on board. In the Foreign Research Reactor Environmental Impact Statement (EIS), the proposed action is for DOE and the Department of State to jointly adopt a policy to manage spent nuclear fuel from foreign research reactors. Marine transport of the spent nuclear fuel from foreign countries and ground transport from ports of entry to potential management sites in the U.S. are included in the management alternatives.

Proposed Action and Alternatives

The description of the proposed action and the alternatives may include information on material and packaging, such as isotopic composition, physical/chemical form, quantity, and container type. The characteristics of the material to be transported and the type of packaging used affects the prediction of impacts, particularly in the accident analyses. The potential hazard of materials should be specifically addressed, including the radiological and chemical hazard. For instance, uranium presents both a chemical and a radiological hazard. The primary hazard associated with uranium depends upon its enrichment, its chemical form, and its physical form.

Consensus on the appropriate packaging is desirable prior to conducting any risk analysis. This is particularly important where multiple sites are involved, and the potential for using different types of packaging for the same material exists. Several risk analysis code input parameters are defined by packaging type, and later changes in packaging could invalidate the risk assessment, resulting in the need to substantially revise the environmental impact analysis. Applicable regulations include Title 49 of the Code of Federal Regulations (C.F.R.), which defines the requirements for transporting hazardous materials in commerce. Like any federal code, 49 C.F.R. is subject to revision, and it is essential that current information is used. If the proposed actions take place over several years, the effects of potential regulatory changes in transportation should also be considered.

When transportation is a major activity, it may be appropriate to describe packing, loading, and unloading activities. A description of the transportation activities to be conducted could include the following elements:

- The number of shipments and drivers (personnel) per shipment
- The carrier (e.g., commercial, military, foreign flag)
- The shipment origin(s) and destination(s), including any intermediate stops at ports for international shipments
- The transport mode, including truck, rail, barge, ocean vessel, and air transport. In cases where two or more transport modes are used, transfer between modes should also be described.

- The estimated distance in kilometers, if known. If the distance is unknown, a conservative estimate may be given. Exact route descriptions should be avoided, as they are subject to change as a result of weather conditions and other influences and may, in some instances, be classified.

When the proposed action is primarily transportation, consider reasonable alternatives for all the major components of the transportation activities. The alternatives in transportation analysis will often involve both alternate transport modes and alternate routes. If alternative modes are not included, it is suggested that the EIS/EA provide reasons for excluding multiple modes of transportation. For example, it may be reasonable to dismiss rail transport as an alternative for a site that has no direct rail access. The additional cost and risk incurred to transport the material by truck to the nearest rail station and transfer it from truck to train may form the basis for dismissal. The Y-12 EA considered a single mode of transportation (truck), while the Foreign Research Reactor EIS considered ground transport by three modes (truck, rail, and barge), plus marine transport by ship.

Transportation alternatives may also involve consideration of alternate origins, destinations, intermediate stops (such as ports), and routes. For actions involving international shipments, the reasons for selecting the port(s) included in the proposed action should be explained. In a case involving the *Environmental Assessment of the Risks of the Taiwan Research Reactor Spent Fuel Project* (DOE/EA-0515), the court noted that the EA did not discuss why Hampton Roads was the port selected for the proposed action and stated that “The Department must set out alternatives and explain the reasons for making the choice that it does” (*Sierra Club v Watkins*, 808 F. Supp. 852, 873 n.38 [D.D.C. 1991]). These reasons could be related to the potential impacts of a port’s use, including overland route distance; security provisions; the port’s experience in handling radioactive and containerized cargo; the types of facilities at the port; the qualifications of the port workers; and the population density of the surrounding area.

The Foreign Research Reactor EIS identified potential ports of entry using screening criteria that included factors such as experience, safety, adequacy of facilities, and population. Many commenters on the draft Foreign Research Reactor EIS cited concerns about the adequacy of longshoremen training, security, radiation exposure, and port congestion. In response to these concerns, DOE agreed that the use of military ports would provide additional security and trained personnel. In the preferred alternative, the Department concluded that foreign marine shipments of research reactor spent nuclear fuel should be made via military ports even though commercial ports would be acceptable.

Environmental Effects

Human exposure to radioactive materials may result in a dose which can be quantified. Analysis of the environmental effects of transportation activities will generally involve the use of transportation risk analysis codes. RADTRAN, RISKIND, and ADROIT are computer codes for analyzing the risks and consequences of radioactive material transportation. Each of these risk analysis codes has unique features which may make its use preferable for a given proposed action. RADTRAN was developed by Sandia National Laboratories under contract to the Nuclear Regulatory Commission during the preparation of the *Final Environmental Statement on the Transportation of Radioactive Material by Air and Other Modes* (NRC 1977). RADTRAN is made available to DOE users and the public on the Sandia National Laboratories TRANSNET computer system. Users may also request an executable version of the code for installation on a mainframe computer (Neuhauser and Kanipe 1992).

RISKIND was developed by the Argonne National Laboratory under contract to the DOE for analyzing radiological consequences and health risks to individuals and the collective population from exposures associated with spent nuclear fuel. Electronic copies are available for use on IBM or equivalent personal computers under the Windows™ environment. Information about Revision 1 of the RISKIND model may be found in *RISKIND—A Computer Program for Calculating Radiological Consequences and Health Risks from Transportation of Spent Nuclear Fuel* (Yuan et al. 1995), including computer software availability. ADROIT was developed by Sandia National Laboratory in support of the Defense Programs Transportation Risk Assessment. Routing models such as HIGHWAY and INTERLINE may be used to predict highway and rail routes, as well as population density for input to the transportation risk analysis models.

No matter which code is selected for analyzing the proposed action, it is preferable that peer review of the input parameters take place prior to beginning the analysis. The accuracy of the results is a function of the quality of the input data, and impacts will vary depending upon the input parameters. For example, the more packages per shipment, the fewer the number of shipments needed and, generally, the lower the impacts. Impacts due to accidents vary with the assumptions concerning packaging and material form. A robust Type B package will have a significantly lower failure rate during an accident than a Type A package and, hence, less material will be released into the environment. Likewise, a liquid is more dispersive than a solid material in an accident.

Using empirical data for input parameters is recommended, whenever it is available. For example, a measured radiation dose rate outside a conveyance such as a truck is superior to a calculated value. When assumptions are necessary, they should be conservative enough to ensure that the results do not underestimate the level of transportation risk, but not so conservative that the resultant risk calculations yield doses that are orders of magnitude greater than what would actually be encountered, or the differences among alternatives are obscured. The more data there are available to define the risk analysis model input parameters, the fewer the number of conservative assumptions that will need to be made and the more realistic the results.

Radiological Effects: Incident-Free Conditions

Incident-free transportation conditions include non-accident conditions and accident conditions that do not result in the release of the radiological contents of the cargo to the environment. Radiological consequences of incident-free transport result from external radiation exposure during transportation, including in-transit and port-related operations. It may be appropriate to analyze health effects from exposure of the general public, involved workers, and uninvolved workers to radiation. The general public consists of persons along the transport route (e.g., pedestrians and persons inside surrounding buildings) and persons sharing the transport route with the vehicle (e.g., passengers in other vehicles on the same route). Persons in the vicinity of a stationary transport vehicle (e.g., when the vehicle is stopped for crew change, passenger transfer, meals, refueling, or inspection) are also included. Involved workers may include packing, loading/handling, and transport personnel, while uninvolved workers may include administrative personnel.

Radiological Effects: Accident Conditions

There are a number of issues associated with transportation accidents which are of particular concern to the public. These include emergency response, the safety of packaging, routing, and attacks by terrorists. The ability of local agencies to respond to accidents is another issue. Incidents such as the Oklahoma City bombing and the more recent bombing of U.S. military facilities in Saudi Arabia have heightened concerns over terrorism. Transportation can be particularly vulnerable to such activities. An appendix was added to the Foreign Research Reactor EIS as a result of public comments in this area.

Radiological effects result from the release of the radiological contents of the cargo to the environment due to an accident. A complete description would include the probability of occurrence, the size of the affected population, the dose, and the potential health effects. The accidents may be traffic related, or due to acts of terrorism or sabotage. Both traffic related accidents and threat from weapons fire and an energetic projectile were assessed in the Y-12 EA.

Effects from dispersive radioactive materials result primarily from the release of respirable radioactive particulates and the subsequent inhalation by persons downwind of the accident site. Other exposure methods include direct radiation from the cloud of airborne material or from contamination on the ground. In the case of undispersed material, only direct exposure from shielding loss would occur. The amount of radioactive material released as a result of an accident depends on the material, the type of packaging, and the conveyance. The packaging type affects the package failure rate during an accident, while material form affects how dispersive the material would be (e.g., solids would disperse less than liquids or gases).

Nonradiological Effects

The nonradiological impacts of transporting nuclear materials are frequently the same as those from transporting nonnuclear materials. One hazard of transporting any material arises from the generation of pollutants during travel (e.g., vehicle exhaust, particulates from tires being abraded on a paved surface, and dust generated in the wake of the vehicle). These pollutants may cause health effects (such as latent cancer fatalities), which can be estimated. Traffic accidents are a second type of hazard that may occur during transport. These accidents may cause serious injuries or death to workers or members of the public as a result of physical trauma, even if no material is dispersed.

Nonradiological transport effects from these causes can be analyzed using the RADCOM computer program. RADCOM uses a series of unit-risk factors in combination with transportation distances to estimate nonradiological transport effects. In general, round trip transport distance is analyzed because the nonradiological risks are also present when the transport vehicle is traveling empty. Nonradiological unit factors reflecting the effect from pollutants generated during normal transport may be derived from the report *Non-Radiological Impacts of Transporting Radioactive Materials* (Rao, Wilmot, and Luna 1982), for use in RADCOM. The Environmental Protection Agency is also developing a health assessment document for diesel emissions. Accident fatality unit factors may be derived from publications such as the *Truck Accident and Fatality Rates Calculated From California Highway Accident Statistics for 1980 and 1982* (Smith and Wilmot 1982), *Accidents of Motor Carriers of Property* (DOT 1978, 1979) for truck transport, *National Transportation Statistics* (DOT 1986) for rail transport.

There may also be nonradioactive hazards associated with the material being shipped. For example, a radioactive material may also present a chemical toxicity risk. The potential impacts from these hazards should also be considered.

The Department of Transportation has an annotated bibliography of recent publications that describe the environmental effects of transportation and related public policy issues. This bibliography is a rich source of current information which may be helpful in addressing non-radiological impacts. Air quality, noise pollution, and hazardous materials are among the categories of issues included. It is accessible through the Internet and may be found at http://www.bts.gov/smart/cat/tea.html.

Environmental Justice

Each federal agency is required to incorporate environmental justice as part of its mission by identifying and addressing disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority and low-income populations (please see Wilkinson, this volume). The following areas may be of particular interest for environmental justice consideration when evaluating impacts related to transportation:

- Selection of transportation route and mode (e.g., by highway, rail, barge) alternatives
- Selection of port city alternatives for international shipments
- Environmental impacts on affected minority and low-income communities along the transportation corridor or adjacent to the origin or destination sites.

The potential impacts to the surrounding population should be considered for both normal and accident conditions. If there is no adverse impact to the surrounding population in general, then it is not necessary to examine subpopulations. On the other hand, if there is an adverse impact, it should be determined if there are any disproportionate impacts to minority and low-income populations. This may be accomplished by using U.S. Census Bureau data to identify minority and low-income census tracts in the affected zone and then applying risk analysis models to determine impacts to these communities.

Minority and low-income households living near the ports of entry and along transportation routes were considered in the Foreign Research Reactor EIS. It was determined that these populations would receive the same low impacts as the general population for incident-free and accident conditions as well as socioeconomically.

Recommendations

The relative importance of transportation activities should be considered in the process of determining the scope of environmental analyses. It is desirable to include transportation activities in the impact analyses if it is a major factor or of public concern. Analysis of transportation activities will generally involve the use of a transportation risk analysis code to determine the human health effects as a result of both incident free transport and accidents during transport. Recently, concerns about terrorism have added another dimension to the analysis of transportation accidents. Environmental justice is another relatively new area of consideration for transportation impact analysis. Early contemplation of these issues will help ensure the scope of the NEPA analysis is appropriate.

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