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ENVIRONMENTAL IMPACT ASSESSMENT IN DEVELOPING COUNTRIES

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THE UNIVERSITY OF OKLAHOMA

GRADUATE COLLEGE

ENVIRONMENTAL IMPACT ASSESSMENT IN DEVELOPING COUNTRIES

A DISSERTATION

SUBMITTED TO THE GRADUATE FACULTY

in partial fulfillment of the requirements for the

degree of

DOCTOR OF PHILOSOPHY

BY

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Norman, Oklahoma

1982

ENVIRONMENTAL IMPACT ASSESSMENT IN DEVELOPING COUNTRIES

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ABSTRACT

This study was conducted to determine the status of Environmental Impact Assessment (EIA) in developing countries; to review assessment methods developed for use in industrialized countries; and to identify methods or salient features of methodologies which are applicable to EIA in the third world. These objectives were achieved through correspondence, computerized database searches and a literature review, an international mail questionnaire, statistical testing and application of a selection procedure to compare methods. The questionnaire consisted of five parts: personal data, current status of EIA, environmental parameters, EIA methodologies, and miscellaneous. It was sent to 700 persons in 139 developing countries and 300 persons in 25 industrialized countries.

Replies were received from more than 150 persons in 72 developing countries and more than 150 persons in 22 industrialized countries. These responses were analyzed and a series of conclusions and recommendations were made. First, EIA is recommended as a planning tool that should be used in developing countries. There was nothing mentioned in the responses which would preclude its use. Second, a conceptual framework for EIA in developing countries is proposed. The basic steps are preliminary activities, impact identification (scoping), baseline survey, impact evaluation, mitigation planning, comparison of alternatives, decision-making and post-auditing.

In addition to these general results, there were several more specific findings, as follows:

(a) The growth of EIA has been rapid in both developing and industrialized countries.

(b) A majority of countries had laws requiring EIA, and an even larger majority had conducted EIAs.

(c) The unavailability of data and expertise are among the problems hampering EIA in developing countries.

(d) Checklists and matrices are among the most appropriate methodologies for identifying impacts and comparing project alternatives in developing countries at the present time.

(e) When evaluating impacts, quantitative assessments are superior to descriptive ones.

(f) The views that public involvement is not encouraged in the third world and that socio-economic factors are rated most important in developing areas were not supported.

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CHAPTER I

INTRODUCTION

> The question is not whether there should be continued economic growth. There must be. Nor is the question whether the impact on the environment must be respected. It has to be. Nor — least of all — is it a question of whether these two considerations are interlocked. They are. The solution of the dilemma revolves clearly not about whether, but about how. (Robert McNamara, President of World Bank, U.N. Conference on the Human Environment, Stockholm, Sweden, 1972, Quoted by Carpenter, 1981)

Statement of Problem

Planners everywhere are faced with the problem of balancing the present with the future. Basic needs such as food, water and shelter must be satisfied if a society is to grow and prosper. But these needs must be met with an eye to the future. No generation possesses the earth. Each holds it in trust for the next. Therefore, it is imperative that present needs be met in such a way that they do not produce insurmountable problems in the future. Because whenever nature is abused, it is mankind who ultimately pays the price.

In the world's developing countries, this balancing of present and future is particularly delicate. In these countries, unfulfilled basic needs represent acute problems. Hunger, disease and inadequate shelter are widespread. Thus, many may argue that development is the only priority at present, with environmental cleanup later, when it is convenient. To quote Jose Jovellanos of the Philippines National Power Corp., "... a developing country should be prepared to suffer environmentally ... we'll clean up once we can afford it." (Water Well Journal, 1982).

Although this approach sounds attractive, it is simplistic and flawed. In the first place, "suffering environmentally" does not only denote the loss of special habitats or scenic vistas. Adverse environmental impacts may directly affect society, and can be worse than the problems that the project sets out to cure. In the past, overfarming has produced dust-bowls (CEQ, 1981), irrigation has spread water-borne disease (Diamant, 1980), and industrialization has polluted land, air and water.

The second problem with the "develop now, clean up later" approach is that it may not be cost-effective. Even where the benefits of a project far outweigh the costs, "clean up later" can be a fallacy. The questions which arise are:

(a) Can clean-up be done later, or will adverse effects be irreversible? and

(b) Will cleaning up at a later date cost less than mitigation measures included in the project design?

Even though the "develop now, clean up later" approach to development has been found wanting, development in the third world must continue. What is needed is a sounder approach to development, which permits decision-making that is based on all the available information. Such an approach is Environmental Impact Assessment (EIA). This is a decision-making tool which attempts to predict, evaluate and mitigate undesirable project impacts. It also addresses the choice between project alternatives, including the no action alternative.

This report is concerned with the balancing of present and future needs. Specifically, it proposes EIA as an aid to development planning in the third world. Environmental impact assessment does not, by itself, preclude the adverse effects of projects. However, it does present a framework within which informed decisions can be made. A judiciously conducted EIA can enhance the selection of the best alternative from among a series of very difficult choices.

Objectives and Scope of Study

The objectives of this study were:

1) to determine the status of EIA in developing countries,

2) to review assessment methods developed for use in industrialized nations, and

3) to identify methods or salient features of methodologies which are applicable to EIA in the third world.

These objectives were achieved through correspondence, computerized database searches and a literature review, an international mail questionnaire, statistical testing, and application of a selection procedure to compare methods.

The major outputs of the study were:

1) a list of developing and industrialized nations,

2) a summary of EIA legislation and practice in developing and industrialized countries,

3) a commentary on attitudes towards EIA, environmental parameters and methodology criteria in developing countries,

4) a conceptual framework for EIA in the third world,

5) a ranking of impact identification (scoping) methods,

6) a ranking of methods for comparing alternatives, and

7) a commentary on third world attitudes to public participation.

Structure of Report

This dissertation contains ten chapters and two appendices. The final section of Chapter I is a summary of the major findings of the study. Chapter II introduces the concept of EIA, including its origins, objectives and components. Chapter III addresses the developing countries. It contains a list of these countries, and discusses some of their special characteristics. Chapter IV is devoted to the types, uses and attributes of EIA methodologies. Together, Chapters II, III, and IV provide the background for the study.

Chapter V is a presentation of the research methods used in this study. It describes the correspondence and database searches, the international questionnaire and the statistical tests. Chapter VI reports the response to the questionnaire. It includes the summary of EIA legislation and practice, as well as the commentary on attitudes towards EIA, environmental parameters and methodology criteria. Chapter VII summarizes assessment methods, and Chapter VIII summarizes prediction techniques. Chapter IX is concerned with public involvement in EIA. Finally, the conclusions to the study are found in Chapter X.

The references cited throughout the report are found after Chapter X. Appendix A addresses industrialized and developing nations. It contains back-up data on the list of nations that was presented in

Chapter III. Appendix B contains the input data and results of the statistical tests which were performed throughout the study.

Summary of Results

The major result of this study is the recommendation that EIA be used as a planning tool in the third world. Nothing was found in the responses to the international questionnaire which would preclude the more widespread use of environmental assessments in developing countries. As long as there is a clear understanding of their uses and limitations, environmental studies can serve as an aid to development planning. On a wider spectrum, they can assist in the balancing of present and future needs mentioned earlier in this chapter.

A second important result is the conceptual framework for EIA in developing countries which is proposed in Chapter VI. The nine basic steps in this framework are preliminary activities, impact identification (scoping), baseline survey, impact evaluation, mitigation planning, comparison of alternatives, documentation, decision-making and post-auditing. The definition, timing and implementation of each step is discussed in Chapter VI. The proposed framework differs from the traditional approach in two main ways. First, the study is timed to run parallel to the engineering design. Hence potential problems can be recognized and solved during the design phase. This should reduce the delays which are associated with "reactive" studies, done after the design has been completed. Secondly, the decision-making step has been separated from the comparison of alternatives. This was done in recognition of the fact that in most cases technologists compare and recommend, but politicians or managers decide. It is recognized that the EIA process will vary somewhat depending upon the laws and social structure of a country. However, it is felt that the proposed framework is a suitable starting point for any developing country which wishes to evolve an EIA system.

In addition to these general results, several more specific conclusions were made. These are as follows.

1) The growth of EIA in both developing and industrialized countries has been quite rapid. Of the 72 developing countries from which questionnaire responses were received, one-half had laws requiring EIA, and three-quarters had experience with environmental studies. Among industrialized nations, the figures were even higher. Of 22 countries in this group from which responses were received, three-quarters had laws and 95% had conducted EIAs. In all countries, there was an overwhelming sentiment that EIA is necesary at the present time.

2) Data on specific environmental phenomena is not readily available in developing countries. What data does exist is often scattered among several agencies. As a result, the use of secondary data (where practical) is advisable in these areas. Also, existing data needs to be cataloged. Finally, the establishment of regional data-banks may be more cost-effective than national efforts.

3) The developing countries suffer from both a shortage of trained personnel and poor allocation of what expertise does exist. The third world has a smaller proportion of trained environmentalists, with a lower average level of educational attainment than the industrialized countries. Compounding this problem is the fact that the majority of trained persons in the developing countries work for the government or in education, while relatively few are employed in industry or consulting. In addition to training more technologists, developing areas should aim at a more equitable distribution among the various employment sectors. Again, the regional pooling of experts may be cost-effective.

4) The view that public involvement is not encouraged in developing countries was not supported by the responses received. In fact, there was no significant difference between the importance rating of this factor in the third

world and the rating in industrialized nations. What was apparent, though, was that there is disagreement about the desirability of public involvement in all countries. The mean response was average importance, while some considered it very important and others unimportant.

5) In general, environmental parameters received importance ratings which were dependent upon familiarity with the problems involved. Where the impacts on a parameter were understood in both developing and industrialized nations, the ratings were essentially the same. On the other hand, parameters which are affected most often by industrial activity received lower ratings in the third world.

6) Contrary to expectations, there was no strong indication that socio-economic factors are considered more important than other factors in developing countries. It would appear that, despite unfulfilled basic needs, technologists in the third world still maintain a balanced view of the environment.

7) At the present time, checklists and matrices are the most appropriate methodologies for identifying impacts in the third world. The checklists which were assembled specifically for use in developing areas scored the highest in the comparison which was done.

8) When evaluating impacts, quantitative assessments are superior to descriptive ones. Further, mathematical, statistical and other numerical methods of impact prediction are more acceptable than "expert opinion" approaches. It is important to appreciate that impact predictions will generally be subject to constraints of cost, time, data and expertise. Even so, the objective should be to make the most accurate predictions based on what is available.

9) The scaling-weighting checklist is the most appropriate methodology for comparing project alternatives in developing countries at the present time. Methods which can be adapted to incorporate local values into the importance weights and scaling functions are particularly valuable for use in third world projects.

CHAPTER II

ENVIRONMENTAL IMPACT ASSESSMENT (EIA)

In this chapter, a general background discussion of EIA is presented. The topics addressed include the concept of EIA, its origins and growth, EIA costs, EIA objectives, some lessons learned from over 10 years of EIA in the United States, and the components of an assessment. The purpose of this discussion is to clarify some of the issues involved in the process of environmental impact assessment.

The Concept of EIA

The phrase environmental impact assessment (or analysis) has no universal interpretation. Instead, the connotation varies from country to country depending in part upon the existing legislation in that country. In the United States of America, an EIA is the document which provides sufficient analysis to decide whether an environmental impact statement (EIS) must be prepared, or whether a finding of no significant impact is appropriate (Canter, 1982). This definition is closely tied in to the requirements of the National Environmental Policy Act (Public Law 91-190). Internationally, the term EIA has a much broader interpretation. Referring to Southeast Asia, Phantumvanit (1982) used the term EIA to describe any evaluation of the environmental consequences of human activities on natural phenomena. He notes that the assessment is a tool to enhance decision-making. One officer of the United Nations Environment Program has defined environmental assessment as the collection and evaluation of all relevant environmental data with a view to advising those who propose a project, be they managers, government or others (Engelmann, 1981). In France, the term EIA refers to the actual study of the environmental consequences of a project, while the environmental impact statement (EIS) is the document which reports the study's findings (Ministere de l'Environnement et du Cadre de Vie, 1981). Canada uses a similar interpretation of these two terms (EIA and EIS) (Jones, 1981).

In addition to its more traditional interpretation, the Environmental Affairs Co-ordinator of the United States Agency for International Development (USAID) sees EIA as a means of system-wide cooperation, integrating the efforts of the various agencies and programs that operate concurrently in any one country (Printz, 1981). In Britain, EIA has been described as the systematic scrutiny and evaluation of possible effects of a project prior to its implementation, with a view to beneficially managing these changes (van Rest, 1981).

The above list of interpretations is by no means complete. However, those included do highlight some of the more important aspects of EIA. These may be summarized as follows.

1) An environmental impact assessment is a study of the effects of any human development on the environment.

2) The actual study involves the collection and systematic evaluation of data.

3) The input and analysis should include persons with different academic backgrounds and views from various levels of decision-making.

4) The output of EIA is intended to enhance decision-making by management in the public or private sectors.

In this study, these four points will be used as the "definition" of the term Environmental Impact Assessment as applied to developing countries.

Origins and Growth

For as long as man has been altering the environment, he has faced the possibility of adverse results. Undoubtedly there were sages, even in the earliest cultures, who cautioned against particular projects for environmental reasons. Although their thoughts are unchronicled, we may assume that their assessment of possible impacts was ad hoc and unsystematic. Since the impacts of the majority of these early projects were localized and relatively minor by modern standards, this approach was adequate.

Industrialization and urbanization altered this situation. Volumes of waste and potency of products increased dramatically. Projects became larger, and their areas of influence increased correspondingly. Further, the adverse effects of many actions became more complex and more persistent. As a result, there developed an increasing concern about the deterioration of the local and global environment, particularly in the industrialized countries. By the late 1960s, several well-organized groups had begun to pressure their governments to take action. Environmental conservation was an idea whose time had come. At the UNEP "World Environment, 1971-82" meeting in Kenya, it was reported that the number of non-government environmental organizations in existance had increased from 2,500 in 1971 to 15,000 in 1981 (Deering, 1982).

The United States of America (USA) has the honor and distinction of being the first country to legislate requirements for systematic assessment of environmental impacts. This is not surprising, since the USA is the most technologically advanced nation in the world, and faces many severe pollution problems. The National Environmental Policy Act (NEPA) of 1969 became law on January 1, 1970. Its thrust was to ensure balanced decision-making (Canter, 1977). As the first law of a new decade, it symbolically represented the Federal Government's recognition of the need to acknowledge environmental concerns.

Within a decade, a host of countries had followed the initiative of the USA. Among the industrialized nations, Canada, Britain, France, West Germany, the Netherlands, Australia and New Zealand have all initiated the use of EIA for appraisal of major projects (Wandesford-Smith, 1980). In reviewing EIA in the region of Asia and the Pacific, Jalal and Thampi (1979) noted that 13 of 23 countries had laws, draft laws, or formal procedures for EIA. These were Australia, Bangladesh, Hong Kong, India, Iran, Japan, the Republic of Korea, Malaysia, Papua New Guinea, the Philippines, Thailand, the Trust Territory of Pacific Islands, and the Union of Soviet Socialist Republics. Of the remainder, it was noted that New Zealand and Pakistan do conduct assessments, although there are no laws or formal procedures requiring it. As these examples clearly show, EIA has been accepted as a useful tool by a significant proportion of the world's nations. Several regional development banks have pledged to ensure the inclusion of appropriate environmental measures in the design and implementation of economic development projects (World Bank, et al., 1980). The insistence on EIA as a pre-requisite for project funding by international lending agencies can only increase its application (Goodland, 1981, and US AID, 1981). It is noteworthy that in the decade of the 1980s, when the effectiveness of NEPA is being questioned in the USA, EIA appears to be gaining strength internationally (von Moltke, 1982).

It should not be inferred from the above that the United States' EIA legislation has been taken as a model by all other countries. Quite to the contrary, several countries have enacted different legislation; and others have chosen to proceed with EIA without specific legislation (Munn, 1982). Both Australia and Canada have opted to leave the procedural and enforcement aspects of EIA to state or provincial legislatures. In Western Europe, the approach has been to integrate EIA into the already elaborate planning approval systems (Foster, 1981). Some Latin American nations, such as Venezuela and Colombia, have taken brief and unspecific references to environmental concerns in statute laws as the mandate to institute EIA (Wandesford-Smith, 1980).

Although environmental assessments are conducted within a variety of legal frameworks, the growth of EIA has been quite remarkable. It is unusual for such a large number of different countries to adopt a common idea in so short a period of time. In the next sections, consideration will be given to two questions that have been raised by countries which are reluctant to implement EIA. These are the cost of EIA, and its objectives (Munn, 1982; and Printz, 1981).

EIA Costs

Costs and Benefits

To many people, the cost of an EIA means only the direct cost of conducting the assessment. This is a valid, though simplistic, interpretation which will be addressed later in this section. Before doing so, however, it is instructive to look at a broader picture of costs and benefits associated with EIA. Four areas of costs and seven areas of benefits associated with environmental impact assessment have been identified (Canter, 1981a). These are listed in Table II.1, and discussed in the following paragraphs.

The direct cost of EIA includes the cost of personnel and equipment to assess the impacts of a specific project. As previously noted, there are those who interpret the cost of EIA as only these direct costs.

The implementation of a project may be delayed by the EIA process. This situation arises most often when the EIA is done late in the project planning process, and least often when the assessment is integrated throughout the planning process. Costs of these delays include increased construction and design costs, and delay of benefits from the completed project. If the project becomes the subject of court action, costs are of two types. The first is the cost of delays

Table II.1: Costs and Benefits of EIA (Adapted from Canter, 1981a)

COSTS	BENEFITS
1. Direct costs of planning and conducting studies	1. The environment is considered during decision-making.
2. Costs due to delays in project implementation.	2. Alternatives are compared on a systematic, interdisciplinary basis.
3. Costs of litigation.	3. Environmental cleanup costs are minimized.
4. Costs of research and development	4. Mitigation measures are included in the design.
	5. Costs due to design changes are decreased
	6. The public can be involved.
	7. Research needs can be identified.

as just described. The second is actual costs of prosecuting and defending the case.

Environmental science and engineering is a relatively new field. As a result there is continuous research and development into techniques and methods to be used in environmental assessments. The cost of this activity is a legitimate indirect cost of EIA.

The primary benefit of EIA is the inclusion of environmental concerns in the decision-making process. As a result of this, possible project alternatives, including the no-action alternative, are compared on a systematic, interdisciplinary basis. These two benefits result in both monetary and intangible gains.

The balance between the needs for development and environmental conservation calls for difficult, often painful, trade-offs. By identifying possible impacts and predicting their magnitude, it is possible to reduce the costs of cleanup by avoiding adverse effects. Even where adverse effects cannot be completely avoided, they can be mitigated.

When assessments are not done, there is the possibility of environment-related design changes being identified after construction has started. These can be particularly costly, since most contractors consider them a great nuisance. When impacts are identified in advance, the possibility of these changes is almost eliminated.

The final two benefits are public involvement and identification of research needs. Public involvement can reduce public opposition by providing information to supplant rumor and misinformation. This can result in both tangible and intangible benefits. The identification of research needs will result in long-term reductions in the direct costs of EIA.

Direct Costs

What does it cost to conduct an environmental impact assessment? Obviously, there is no unique answer to this question. Whether expressed as a percentage of total project cost or as an absolute dollar figure, the direct cost of an assessment is a function of many variables. These include project type and magnitude, country involved, extensiveness of assessment and whether the assessment is done by government or private enterprise. In light of the above, data on direct assessment cost is cited only to give a very general idea of the costs involved.

Ludwig (1982) suggested a scale of budget allowances for fees to cover the direct cost of environmental studies in Thailand. This is summarized in Table II.2. His scale runs from $0.25 million US for very large projects to $11,000 US for relatively small ones. Expressed as a percentage of construction costs, EIA direct costs vary from 0.1% for large projects to 1.10% for small ones. This is in agreement with the overall figure of 0.6% cited by Phantumvanit (1982) for the Southeast Asian region.

Meagher and Scott (1980) presented data on actual costs of preparing EISs for 56 wastewater treatment plants in the USA. This is summarized in Table II.3. The trend here is the same as noted for Thailand, although the actual costs are different. The direct costs of conducting the EIA ranged from 0.08% for projects in the group costing

Table II.2: Fee Allowances for EIA Studies in Thailand (Adapted from Ludwig, 1982)

Construction Cost of Project, $US Million	Fee for EIA Study	
	$US Thousands	% of Construction Costs
250	250	0.10
200	220	0.11
150	188	0.13
125	170	0.14
100	150	0.15
80	132	0.17
60	112	0.19
50	101	0.20
40	90	0.22
30	76	0.25
20	61	0.31
10	41	0.41
8	36	0.45
6	31	0.51
4	24.5	0.61
2	16.5	0.83
1	11	1.10

Table II.3: Direct Cost of Preparing EISs in the USA
(Adapted from Meagher and Scott, 1980)

Cost of Originally Proposed Project ($US Millions)	Cost of Preparing EIS (% of Originally Proposed Cost)
less than 1.99	5.4
2 to 4.99	3.6
5 to 9.99	2.6
10 to 19.99	0.9
20 to 49.99	0.4
50 to 99.99	0.3
more than 100	0.08

more than $100 million US, to 5.4% for projects in the group costing less than $2 million US. Zigman (1978) quoted slightly lower costs (.01% to 2.8%) for environmental reports prepared in compliance with California's Environmental Quality Act.

It can be seen from the data in Tables II.2 and II.3 that the cost of conducting an environmental assessment is generally of the order of one percent of total project cost. Though this seems to be a rather small proportion, the actual dollar value can be large on major projects. However, to be seen in proper perspective the direct cost of EIS preparation should be compared to the possible benefits derived, not just the overall project cost. This is not a simple task. Many project benefits and some indirect costs are difficult to identify, and even more difficult to quantify in dollar terms.

Objectives

A second concern often voiced by opponents of EIA legislation relates to the objectives of environmental assessments. One popular misconception is that EIA, by its very nature, will slow down or halt economic development. In this section, this myth will be explored. In addition, several ways in which EIA can be used to improve the quality of economic development will be discussed.

To a great extent, the idea that EIA retards development has been fostered by the international news media. Over the last two decades, the environmental movement has been pictured as placard-wielding mobs blocking the progress of some major project. By association, many people have come to believe that EIA is simply a legalized approach to this same objective. If this were true, EIA legislation would be suicidal to many of the world's poorer countries. In fact, quite the opposite holds. Given the magnitude and international nature of many current development projects (Munn, 1982), it is the lack of proper assessments which may prove catastrophic.

Jacobs (1981) has outlined three premises which sustain the idea of EIA. These may be restated as objectives, as follows:

- to objectively and scientifically predict the impacts of a project; to assess these impacts; and (where possible) to mitigate them.
- to equitably distribute the costs and benefits of the proposed project, either through project design or through mitigating measures.
- to permit all affected parties to have an input into the project study, and to arrive at a concensus which is acceptable to all.

Jacobs was very careful to point out that these objectives will not be attained on every project. Three problems are often encountered. The first is that impacts cannot always be predicted in a "scientifically detached" manner. Particularly with social and cultural impacts, emotional responses often come into play. Secondly, equitable distribution may not be possible. Some projects, by their very nature, adversely affect one geographical area in order to provide benefits to another. Finally, all affected parties will not abide by the "rules of the game". Some groups will prefer to operate outside of the structured forum of public participation.

It should be noted that Jacobs' premises do not explicitly address project cancellation. Instead, the emphasis is on the amelioration of effects. This approach is a very realistic one for developing countries. Certainly, the action/no action decision must be made. But in many cases the problem being addressed is so acute that some action is inevitable. Under those circumstances, "no action" does not represent a feasible alternative.

Nancarrow (1974) summarizes the objective of EIA as ensuring "that the proposed project is optimized from the environmental as well as the technical and economic standpoints; and to determine whether or not the project will serve the public interest". Here again, the emphasis is on project optimization rather than project cancellation.

The action/no action decision is only one aspect of an environmental assessment. Other aspects include the choice of alternatives, the identification of unavoidable adverse effects, and the planning of mitigating measures. These three hold even when the action/no action decision does not: i.e., where the project is of a "must do" nature. Thus, a well-conducted EIA may be seen as an aid, rather than an obstacle, to economic development. By choosing the soundest alternative and by identifying and mitigating against unavoidable adverse effects, project planners can satisfy long-term commitments as well as short-term goals. In the section which deals with the components of an assessment, the aspects of choice of alternative, identification of effects and planning of mitigation will be discussed in greater detail.

Lessons Learned in the United States

In the twelve years of EIA in the United States, many lessons have been learned. Some of these are applicable in the Third World, and noting them would save the costs of repeating mistakes. The Honorable Elmer Staats, former Comptroller-General of the U.S., has summarized ten lessons learned as follows (Staats, 1982):

1) There are limits to quantification. Time and effort expended in assigning numerical values to intangibles are not always justified.

2) EIA is as much an art as it is a science.

3) The tradeoff between timeliness and thoroughness must be emphasized. A superficial assessment is unacceptable. Equally unacceptable is a thorough assessment which unduely delays project implementation.

4) Technologists must work closely with decision-makers to ensure that the questions being answered are those which are asked. A mis-directed assessment is costly since it is of little or no help in decision-making.

5) Macro-evaluations should be limited. Work should be handled in manageable chunks.

6) Good evaluations do not necessarily result in good decisions. However, they do assist those who wish to be objective.

7) Credibility is of vital importance. The technologist must be objective and impartial. "Fine-tuning" should be left to the decision-makers.

8) The technologist should strive to anticipate the needs of the decision-makers as well as upcoming issues.

9) The final report should not be too technical. It should be written with a specific audience in mind.

10) Where possible, previous studies should be referred to. Sometimes synthesis can be more useful than gathering extensive new data.

Components of an Assessment

This section consists of an analysis of flow-charts relating to the assessment process. In this discussion of flow-charts, the important components of an EIA will be identified. The flow-charts which are analysed were developed by Canter (1977), Raman, Bowonder and Sundaresan (1980), Engelmann (1981) and Ontario Ministry of the Environment (1981).

Canter's (1977) flow chart, based on US practice, is shown in Figure II.1. The steps shown are as follows:

1) Basic Activities include preliminary design of the various project alternatives, review of applicable laws, regulations and local ordinances, and the selection of an interdisciplinary team to conduct the assessment. The expertise contained in this team must be capable of assessing physical-chemical, biological, cultural and socio-economic impacts. Finally, the category "basic activities" includes the identification of possible impacts, through review of literature on similar projects.

2) The Description of the Affected Environment is sometimes called the baseline study. This activity involves identification of environmental factors, and organization of these factors into physical-chemical, biological, cultural and socio-economic categories. Some impact identification results from this activity.

3) Impact Prediction and Assessment is the most important technical element of an EIA. Here, the magnitude of environmental changes resulting from each project alternative is computed. These computed results must then be interpreted to determine their significance.

4) The Selection of the Proposed Action is based on the assessment of the impacts of each alternative. This is no simple task, since each alternative will have positive and negative aspects. The final choice should be based on the predicted impacts, taking into account the social, cultural and political values of the country or region being affected.

5) The final output of the environmental assessment should be a Written Document. This may be a brief letter-report (on very small projects) or an extensive document several volumes long (on very large projects). Regardless of its size, this document should clearly define the decision made, and give the inputs that resulted in this decision.

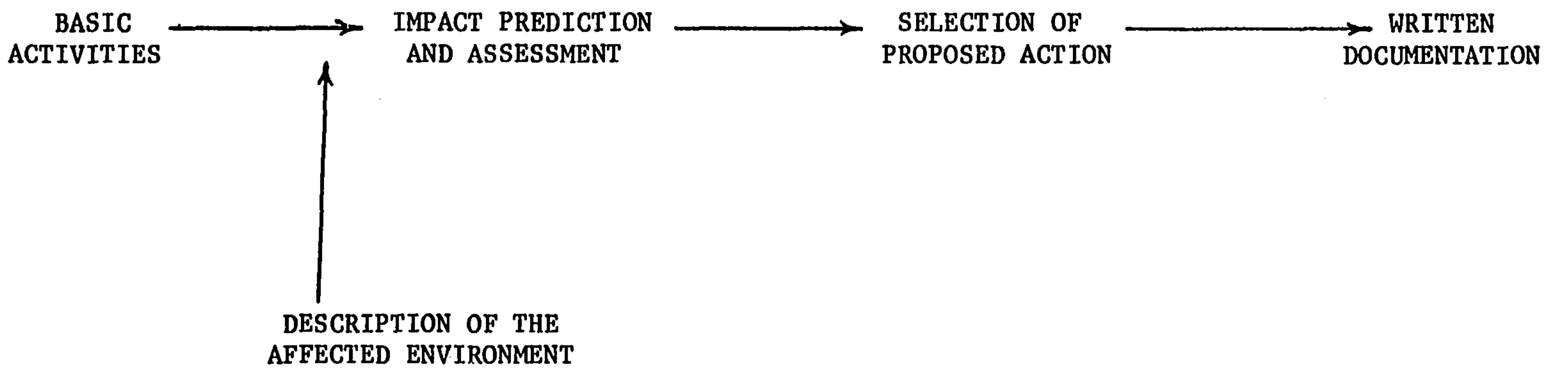


Figure II.1: Framework for Environmental Impact Studies (From Canter, 1977)

Figure II.2 is the flow-chart developed by Raman, Bowonder and Sundaresan (1980). This is representative of the EIA process in India. It includes six steps as follows:

1) The Project Description is a general statement of the nature, aim and scope of the development being planned.

2) The Information step is analogous to Canter's Description of the Affected Environment. Information collected includes economic, demographic, meteorological, technological and historical data.

3) Identification and Evaluation of project impacts is analogous to Canter's Impact Prediction and Assessment. This step involves the identification of effects, the prediction of their magnitude, and the evaluation of their significance.

4) Suggestions refers to the identification of unavoidable impacts and the design of measures to mitigate them.

5) Analysis and Assessment is the step in which all project alternatives (including no action) are compared. This step includes cost-benefit analyses, risk analysis, and weighted rankings.

6) The Impact Statement is the documentation of the study. It should contain a description of the project and the affected environment, a listing of the alternatives considered, and recommendations of the preferred alternative and mitigation measures.

The flow-chart in Figure II.3 is Engelmann's (1981) recommended approach to producing environmental assessments of development programs in a timely and economical manner. The assumption is that the EIA is conducted by a "core group" who can solicit inputs from experts as the need arises. The process is divided into steps and activities as follows:

1) The Plans and Intentions of government, industries and citizens are solicited. Basically, this step asks the questions, "Where are you now?" and "Where do you want to be?".

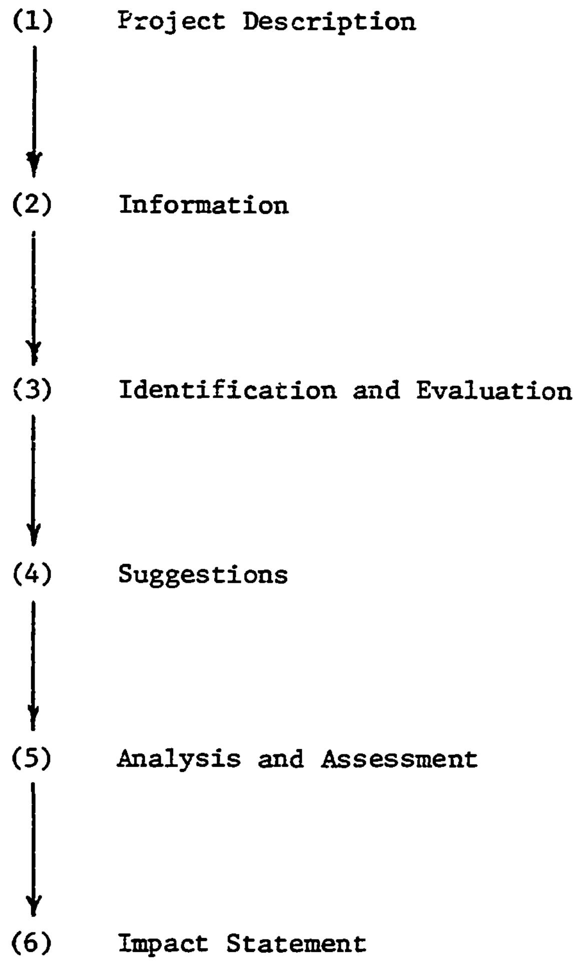


Figure II.2: Sequence of Operation for an Environmental Impact Statement (From Raman, Bowonder and Sundaresan, 1980)

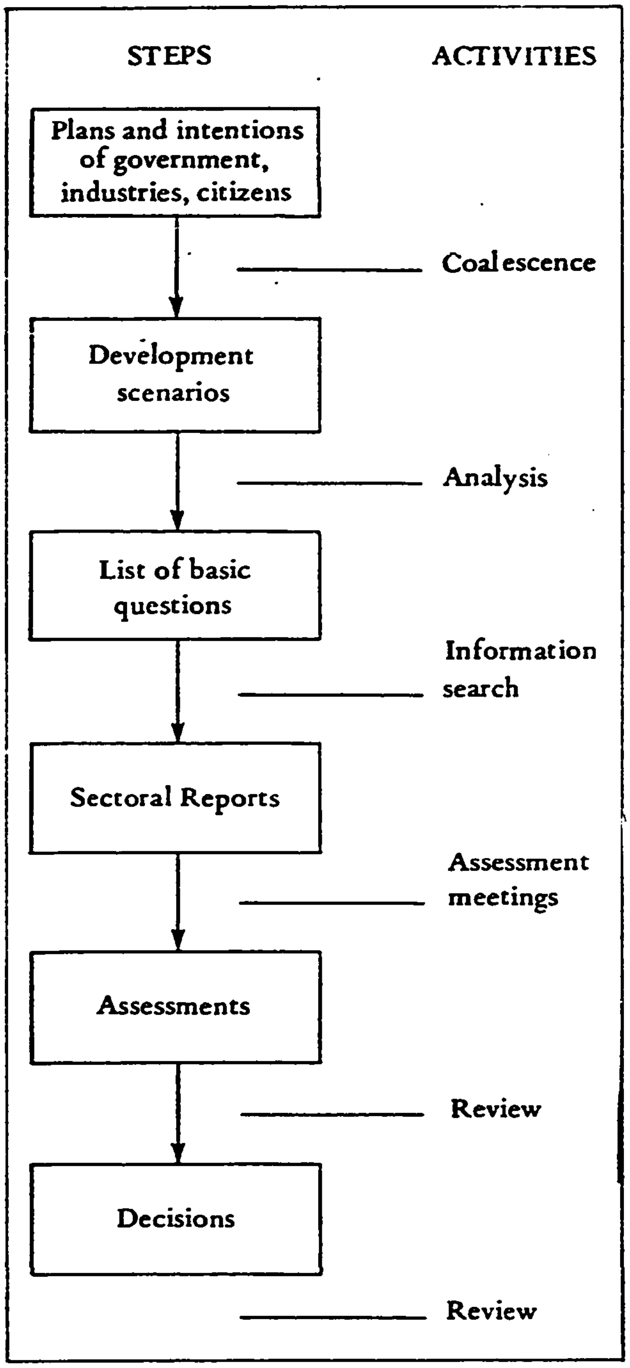


Figure II.3: Summary of Steps and Activities Required to Produce an EIA (From Englemann, 1981)

2) The information gathered in step 1 is coalesced into a series of alternative Development Scenarios. Each of these is a means of getting from "where you are" to "where you want to be".

3) Careful analysis of each scenario will yield a number of Basic Questions which must be answered in order to assess the benefits and ill-effects of the scenario. These questions will relate to all aspects of the environment: physical-chemical, biological, cultural and socio-economic.

4) An information search into the questions identified in step 3 is necessary. This is done by the experts available to the core group. The results of this search are contained in Sectoral Reports. Usually, one report is prepared by each expert, dealing with his area of specialization. For ease of assimilation, a standard report format is recommended.

5) The core group reviews the sectoral reports at assessment meetings. Based on the benefits and adverse impacts predicted in the reports, the core group evaluates the various scenarios. These Assessments along with recommendations on the preferred course of action are forwarded to the decision-makers.

6) After a review of the assessments and recommendations made by the core group, Decisions are made by the competent authorities. These decisions are themselves subject to review.

The flow-chart in Figure II-4 shows an environmental planning process conducted in compliance with the laws of the Province of Ontario, Canada (Ontario Ministry of Environment, 1981). The steps involved are as follows:

1) The first step is to identify the purpose of the project. This involves a description of the problem to be solved or the opportunity to be taken advantage of. It is noted that these objectives might change as the investigation proceeds.

2) All reasonable alternatives must be identified. All must be researched and evaluated. One will ultimately be chosen.

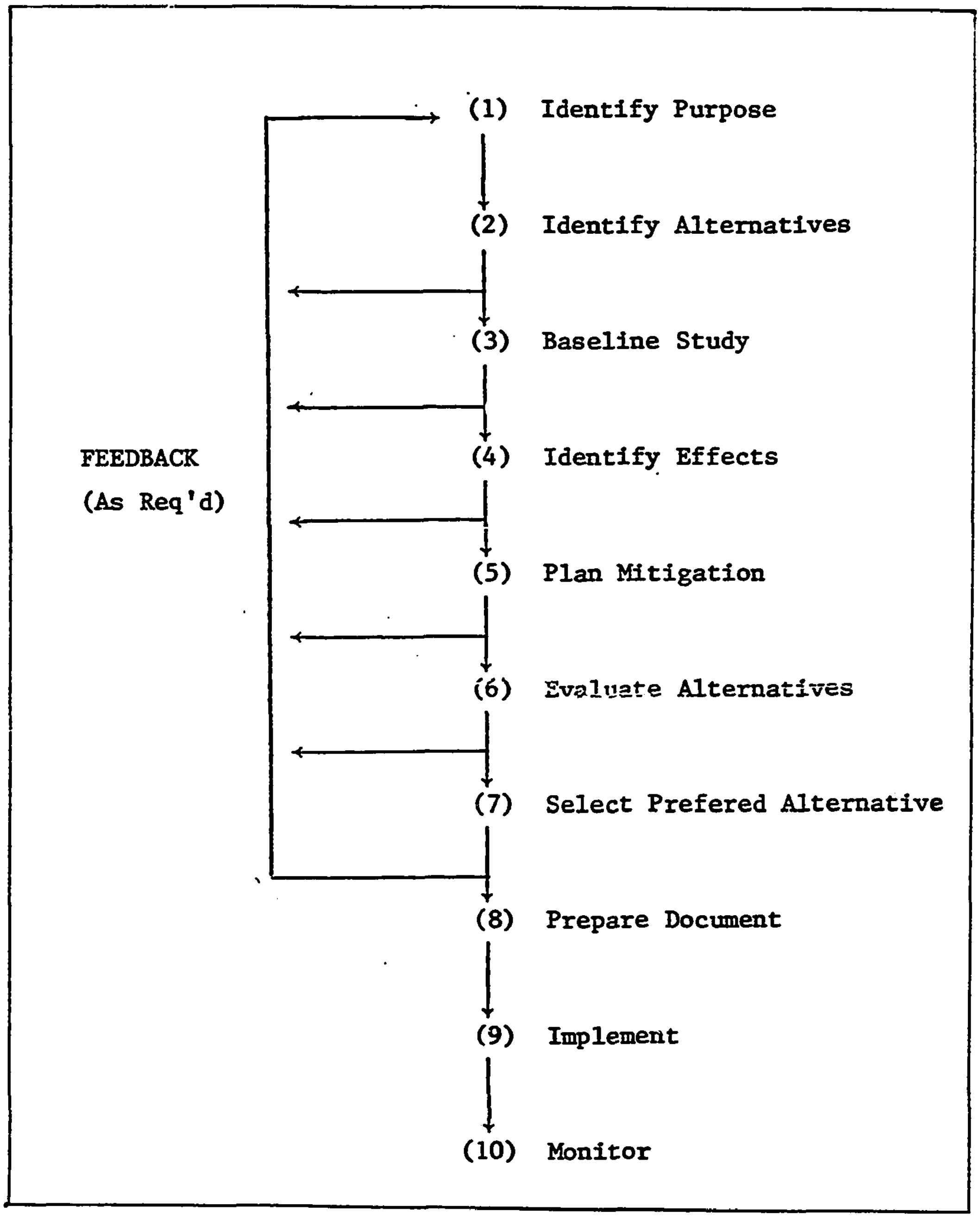


Figure II.4: Diagram of an Environmental Planning Process (from Ontario Ministry of Environment, 1981).

3) The baseline study is an inventory of data on the environmental components which may be affected directly or indirectly by the alternatives. The amount, detail and type of data gathered will vary from project to project. If the ultimate use of the data is kept in mind, the data collected will tend to be more relevant.

4) The positive and negative effects of each alternative must be identified.

5) Whenever possible, the assessor must plan mitigation of adverse effects.

6) The evaluation of alternatives is based on the benefits and demerits of each alternative, taking into account the effects of mitigation measures. Included here is the quantification of effects identified in step 4.

7) The choice of preferred alternative is based on the evaluations done in step 6. The selected alternative is the one which gives the best trade-off between benefits and costs (both environmental and social).

8) A document must be prepared for review by the Ministry of Environment.

9) Assuming the project is approved, the prefered alternative is implemented. All mitigation measures planned in step 5 must be included.

10) The actual effects of the implemented project must be monitored. The data collected benefits future projects of a similar nature.

From these four flow-charts, it can be seen that the EIA process varies from country to country. In spite of this, there are several important steps which are common to most (if not all) EIAs. Based on these four flow-charts, some less formalized discussions of the EIA process, and responses to the international questionnaire, a conceptual framework for conducting EIA in developing countries was constructed. This is presented in Chapter VI.

In order to facilitate the EIA process described in this section, many methodologies have been devised. These will be discussed in Chapter IV. Before doing that, however, it is instructive to look at those countries which are considered "developing" and identify some of their special characteristics which would affect the implementation of EIA. The next chapter gives a brief background commentary on the present dichotomy into developing and industrialized nations in the world; presents a list of developing and industrialized nations; and discusses some characteristics of developing countries.

CHAPTER III

THE DEVELOPING COUNTRIES

A Global Perspective

In any study of EIA in developing countries, it is useful to identify the developing countries and their common characteristics. No clear definition of "developing countries" was found in the literature reviewed for this project. In fact, the frequently used terms "poor countries", "the third world", "developing countries", and "underdeveloped nations" each assume different shades of meaning depending on context. As a result, it was necessary to assemble a list of "developing" and "industrialized" nations for the purposes of this study. The first section of this chapter gives a brief summary of the historical background which has resulted in the present global situation. The following section will describe the rationale used in assembling the list of industrialized and developing countries, and presents the list itself. The final section is a summary of special characteristics of developing countries, many of which will affect the implementation of EIA in these nations. The data used in classifying the world's nations is found in Appendix A. This Appendix also contains some discussion of why particular countries fall into one or the other category.

The Imperial Era

The present dichotomous situation involving the world's nations has its roots in the era of empire-building by the nations of Western Europe. A convenient starting date for this discussion would be the first voyage of Columbus in 1492. With the discovery of the New World, the search for empire began in earnest. Over the next four centuries, Spain, Portugal, France, Britain, the Netherlands, Germany and Denmark all established and attempted to maintain overseas colonies (Henry, 1972).

The colonial empires were fairly uniform in economic arrangements. The colonies were the producers of raw materials, and the "motherland" converted these to finished products. Thus, industrialization progressed in the colonizer nations, but stagnated in the colonies (Williams, 1961). These systems were so well entrenched that even after attaining independence many former colonies retained the status of raw material producers and failed to develop industries.

Another facet of colonial status which affects today's developing countries relates to education. Because the colonies were raw material suppliers, and because government was imposed from abroad, skilled technicians and university graduates were deemed unnecessary. As a result, the very few who were chosen for higher education were sent to the metropolitan country for schooling (Williams, 1964). Late in the colonial era, some universities were established in the colonies. Unfortunately, these were affiliated to and modeled upon European institutions. Thus, they produced graduates who would easily fit into the empire system, but who were ill-equipped to lead their nations to independent development. Even today, many third world universities produce a superfluity of linguists and social scientists, but a paucity of engineers, architects and scientists.

The collapse of the empires started in the New World. In 1776 the United States declared its independence from Britain. Haiti won its independence from France in 1808. Spain lost the majority of its mainland Latin American colonies between 1810 and 1840. It is interesting that of these early decolonised nations, only the U.S. has been able to become an industrialized power. The empires then remained relatively stable for about a century, from 1840 to 1940. However, the period since the end of World War II has seen rapid decolonization in Africa, Asia, the Middle East, the Pacific, and the Caribbean (U.S. Department of State, 1981).

The Present Situation

At the present time, there are a host of terms used to describe dependent territories. Britain still has some colonies. The British Associated States and the French and Portugese Overseas Territories are former colonies on the way to independence. France, Spain and Denmark all have overseas provinces which are supposed to be integral parts of the mother country. A review of the membership list of the United Nations (UN, 1981) and the World Bank Atlas (World Bank, 1980b) identified 184 separate political units in the world. Bona fide offshore islands were treated as part of the mainland nation. These included the Channel Islands and the Isle of Man of Britain, the Faeroe Islands of Denmark, the Azores of Portugal and the Galapogos Islands of

Ecuador. However, several areas which are constitutionally linked to a metropolitan nation are treated as separate entities. This is because these areas are socially and economically distinct and physically separated from the mother country. Such areas include the Canary Islands (Spanish Territory), Greenland (Danish Territory), and Martinique, Guadaloupe and French Guiana (French Territory).

The detailed classification of nations is contained in Appendix A. The following section contains a summary of the rationale used to classify countries, and the actual list of nations.

Listing of Nations

Rationale

The basic rationale used in classifying the countries of the world was their status in five previous classifications. These were

-- Membership in the "Group of 77" at the United Nations (UN),

-- The World Bank's classification,

-- The membership lists of the International Development Association (IDA),

-- The book "Basic Human Needs" by J. and M. McHale, and

-- The doctoral dissertation entitled "A Mathematical Model for Predicting Water Demand, Waste Water Disposal and Cost of Water and Waste Water Treatment Systems in Developing Countries" by M.I. Muiga.

In general, the following guidelines applied. Members of the Group of 77 are developing countries. Countries classified as low or middle income by the World Bank are developing. Some countries in the World Bank "capital-surplus oil exporting" and "centrally planned economy" categories are also developing. Part II members of the IDA are developing, as are nations in the McHales' groups C, D and E, and those included in Muiga's survey.

In the majority of cases, there was agreement between the five classifications on the status of a given country. That status was used in this study. In a few cases, however, there was disagreement. There were also cases where countries were included in two or fewer of the previous classifications. When either of these occurred, development status for the present study was decided based on social, economic and political indicators. In Appendix A, case-by-case discussions are presented.

Classification

The classification of each of the 184 nations and dependencies is listed in Table III.1. The table is subdivided into four geographical regions: Africa and the Middle East, the Americas, Asia and the Pacific, and Europe. These regions are based on those used for the UN Economic and Social Commissions. The distribution of developing and industrialized countries is shown in Figure III.1. Certain trends are immediately apparent: the correlation between colonial status and development, the correlation between climate and development, and the tremendous diversity among the third world countries. During the imperial era, the colonizer nations were all European, and the empires were built in Africa, Asia, and the Americas. Of the 150 nations classified as developing in this study, 67 are in Africa and the Middle East, 40 are in the Americas, 37 are in Asia and the Pacific, and only 6 are in Europe. Conversely, of the 34 industrialized countries, 26

Table III.1: Developing and Industrialized Nations

A) AFRICA AND THE MIDDLE EAST

DEVELOPING:

Algeria	Angola	Bahrain	Benin
Botswana	Burundi	Cameroon	Canary Is.
Cape Verde Is.	Central African Rep.	Chad	Comoros
Congo	Djibouti	Egypt	Equatorial Guinea
Ethiopia	Gabon	Gambia	Ghana
Guinea	Guinea-Bissau	Iran	Iraq
Ivory Coast	Jordan	Kenya	Kuwait
Lebanon	Lesotho	Liberia	Libya
Madagascar	Malawi	Mali	Mauritania
Mauritus	Morocco	Mozambique	Namibia
Niger	Nigeria	Oman	Quatar
Reunion	Rwanda	Sao Tome & Principe	Saudi Arabia
Senegal	Seychelles	Sierra Leone	Somalia
South Africa	Sudan	Swaziland	Syria
Tanzania	Togo	Tunisia	Uganda
United Arab Emirates	Upper Volta	Yemen Arab Rep.	Yemen People's Rep.
Zaire	Zambia	Zimbabwe	

INDUSTRIALIZED:

Israel

B) THE AMERICAS

DEVELOPING:

Anguilla	Antigua	Argentina	Bahamas
Barbados	Belize	Bermuda	Bolivia
Brazil	Cayman Is.	Chile	Colombia
Costa Rica	Cuba	Dominica	Dominican Rep.
Eduador	El Salvador	Falkland Is.	French Guiana
Grenada	Guadaloupe	Guatemala	Guyana
Haiti	Honduras	Jamaica	Martinique
Mexico	Monserrat	Nicaragua	Nederlands Antilles
Panama	St. Lucia	St. Vincent	Surinam
Trinidad & Tobago	Uruguay	Venezuela	Virgin Islands (US)

INDUSTRIALIZED:

Canada	U.S.A.

Table III.1: (Continued)

C) ASIA AND THE PACIFIC

DEVELOPING:

Afghanistan	American Samoa	Bangladesh	Bhutan
Brunei	Burma	China	Fiji
French Polynesia	Guam	India	Indonesia
Kampuchea	Kiribati	Korea (North)	Korea (South)
Laos	Macao	Malaysia	Maldives
Mongolia	Nepal	New Caledonia	Pakistan
Papua-New Guinea	Philippines	Portugese Timor	Solomon Is.
Sri Lanka	Taiwan	Thailand	Tonga
Tuvalu	U.S. Trust of Pacific Is.	Vanuatu	Vietnam
Western Samoa			

INDUSTRIALIZED:

Australia	Hong Kong	Japan	New Zealand
Singapore			

D) EUROPE

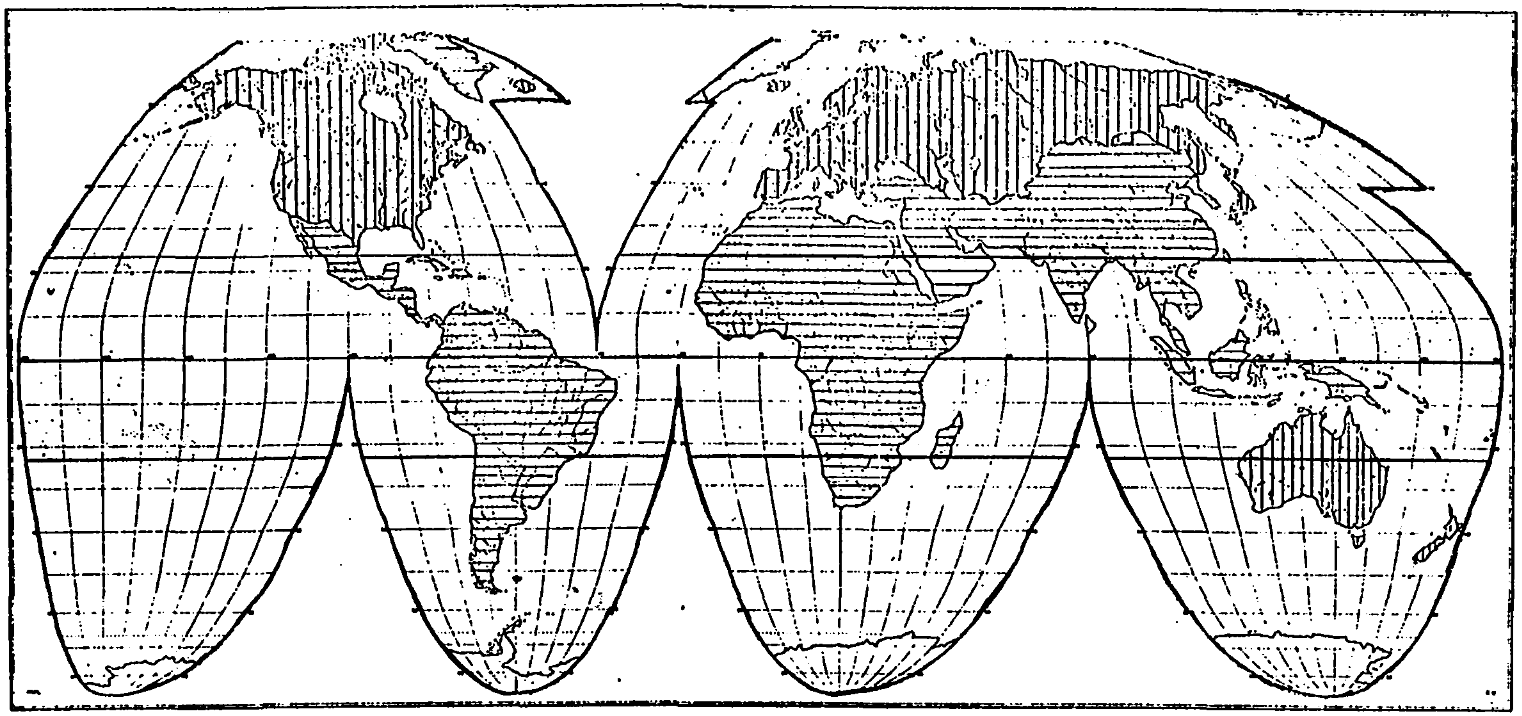
DEVELOPING:

Albania	Cyprus	Gibraltar	Greenland
Malta	Turkey		

INDUSTRIALIZED:

Austria	Belgium	Bulgaria	Czechoslovakia
Denmark	Finland	France	Germany (East)
Germany (West)	Greece	Hungary	Iceland
Ireland	Italy	Luxemburg	Netherlands
Norway	Poland	Portugal	Rumania
Spain	Sweden	Switzerland	United Kingdom
USSR	Yugoslavia		

NOTE: For details of each country's social, economic and political status, see Appendix A.



||||| = Industrialized Areas   ☰ = Developing Areas

Figure III.1: Industrialized and Developing Countries are in Europe. The reasons for this situation are found in the economic structure of the empires, which was briefly discussed earlier in this chapter.

The vast majority of the world's developing nations are in the tropical zone. The relationship between climate and development is a very complex one, and is not yet fully understood. However, the following quotation is particularly apt.

> It is in no way claimed that climate has a mechanical one-to-one relationship to economic development or that climate with its effects is the only ruling constraint on economic development or that if the effects of climate are removed as a ruling constraint in today's poor countries, development will be unbounded. What is claimed rather is that in today's poor countries climatic factors will usually be found to have an important hampering effect on economic development through their impact on agriculture directly or through the diseases and pests afflicting animals and plants, on mineral discovery and on man himself through disease; that these effects need to be better understood; and that a high priority needs to be given to investment in research to find ways to minimize the adverse impacts of climate and to find ways to turn the particular manifestations of the local climate to advantage (A.D. Kamarck, quoted by McHale and McHale, 1977).

There is no typical third world nation. In size and population these countries range from some of the world's largest (Brazil, India, China, all larger than 1.3 million square miles) to some of the smallest (St. Lucia, Macao, Seychelles, all smaller than 1,000 square miles). Population densities range from crowded (Barbados with 500 persons per square mile) to sparse (Greenland with 20 persons per square mile). Individual third world countries embrace vastly different political, social and economic systems. In short, each country faces a unique mix of resources, philosophy and problems.

In this study, the lists of industrialized and developing countries were assembled to achieve two objectives. First, the countries which are classified as developing were reviewed for common characteristics which affect the implementation of EIA. Second, the classifications were used to determine where the international questionnaire should be sent. This latter will be amplified in a later chapter. The former is considered in the next section.

Special Characteristics

The countries classified as developing in the last section are a very diverse group. Thus, attempts to find common characteristics shared by all would probably prove futile. There are, however, some characteristics which are shared by a majority of developing countries. This section is devoted to a discussion of those characteristics of developing countries which would affect the implementation of EIA. These are unfulfilled basic needs, relative project magnitude, few trained personnel, limited available data, and social factors.

Unfulfilled Basic Needs

Basic human needs include air, water, food, shelter, health care and employment. With the exception of clean air, these necessities are in scarce supply in the third world when compared to industrialized nations (McHale and McHale, 1977). Until the standard of living of the suffering millions can be lifted above that of marginal existance, such considerations as preservation of scenic vistas seems spurious. However, even in the most deprived situations EIA has a role to play. An attitude of "develop at any cost" may serve short-term ends, but will create long-term problems. Where leaders of developing countries have adopted a "tunnel vision" approach in the past, problems have arisen. Examples include the creation of deserts by over-felling of trees (World Bank, 1975) and spread of water-borne diseases by irrigation projects (Diamant, 1980; Hafez and Shenouda, 1978). Such episodes can be avoided if side-effects of projects are identified in advance. There are cases of projects where the do-nothing alternative must be rejected because of existing unfulfilled needs. Even in these cases, the use of EIA to establish environmental interrelationships, select project alternatives and identify mitigation measures is desirable. To highlight only the immediate goals and neglect long-term or side effects can lead to disaster. Identification of the bad as well as the good facilitates balanced, sound design. Where a methodology is used to compare project alternatives, it is important that the weighting given to socio-economic factors should accurately reflect the situation within the country.

Project Magnitude

Closely related to unfulfilled basic needs in developing countries is the magnitude of many projects in the third world. Many developing countries are embarking upon projects which are very large in relation to their physical size and economy. This is quite different from the development pattern of industrialized areas. In Europe and North America, national development progressed more slowly, in response to the gradual increases in needs. It was, in effect, evolutionary. Present developing countries do not have this luxury.

They are faced with a great need that must be filled very rapidly. The response is often very large projects, the results of which will be revolutionary.

Two examples of large projects in developing countries are the Amazon Basin developments in Brazil and the Pa Mong dam on the Laos-Thailand border. The former involves the replacement of large tracts of tropical rain forest. Its initial objective was the replanting of most of Brazil's Amazon Basin with food and forest crops. Since 40% of the world's tropical rain forest area is in the Brazilian Amazon, the cost of an environmentally unsound approach is put in perspective (Goodland, 1980). The Pa Mong dam on the Mekong river will, when built, affect four countries: Vietnam, Kampuchea, Laos and Thailand. The environmental effects of the project include changes in river utilization on the village level, forests and wildlife, industries and human settlements. A major adverse effect may be reduction in food production in the Mekong delta. Unless these effects are recognized, and mitigation planned where necessary, this project can become a further stress on an already troubled region. Fortunately, it appears that the planners of this project have recognized the need for an environmentally sound design (Ludwig, 1982; Lohani and Kan, 1981).

Even where a project is not large by international standards, it may be large in relation to the country where it is being implemented. Such is the case of the Caroni-Arena Water Supply Project in Trinidad, West Indies. Harnessing the island's largest river, this project is expected to almost double the nation's supply of potable water. Thus, a failure would affect the entire population in one way or another (Trintoplan, 1976).

Whether a project is large in absolute terms or in relation to a country's size, the cost of error is very high. Yet third world projects are often driven by an unfulfilled basic need, such as food in Brazil and safe water in Trinidad. What is needed, therefore, are assessment methodologies which address all parameters of the environment and the interrelationships between these parameters. They should identify potential impacts, and predict their magnitude as accurately as the available data permits. Further, the results of impact predictions should be useful in planning the mitigation of adverse impacts. Finally, the methodologies should permit systematic comparison of alternatives.

Trained Personnel

The lack of trained personnel in developing countries relates both to the limited number of indigenous technologists and to the deployment of these persons. The evolution of educational institutions in the former colonies has been discussed earlier in this chapter. Compounding this problem is the migration of technologists from developing to industrialized countries: the brain drain. Most studies into this phenomenon have yielded inconclusive results due mainly to a paucity of data. As a result some authorities cite the brain drain as a major deterrant to development, while others dismiss it as insignificant. However, the following are generally agreed. First, the ratio of technologists to general population is higher in industrialized nations than in developing ones. Second, the established lines of migration are from developing to industrialized countries, and between industrialized nations. Migration between developing countries is far less significant, and migration from industrialized to developing areas is practically non-existant. Third, the process of development requires skill and trained technologists. Local conditions may retard development when expertise is available, but development without expertise is not feasible (UNESCO, 1971; and Glaser, 1978).

Another problem in developing countries is poor utilization of available expertise. Governments and activities are usually structured along the lines of disciplines and geographic areas. This makes integration and coordination difficult. It also inhibits the interdisciplinary approach that is necessary for effective impact assessment (Engelmann, 1981). Further, the available expertise in the third world is mainly in the social sciences. Medical doctors, engineers, agriculturists and natural scientists are in short supply. Thus, the balanced diversity of skills needed for development is lacking (Committee on the International Migration of Talent, 1970).

The solution to the problem is not simply the importation of experts, since foreign exchange is unavailable to many developing areas. Further, local input is desirable in EIA studies. Therefore, assuming that the EIA is to be done wholly or in part by local technologists, utilized methodologies would have to be only moderately complex. This does not mean that these countries would be limited to using second-rate technology. It does, however, require recognition of the fact that methodology complexity, of itself, does not signify improvement.

Available Data

Parallel to the problem of limited trained personnel is the lack of environmental baseline data. Munn (1982) notes that one of the factors detering environmental assessments in developing countries is the insufficiency of baseline data and financial and technical resources to generate this data. Printz (1981) also comments on the scarcity of data in third world countries. In fact, this problem plagues parts of the developed world as well as the developing areas. It stems from a tendency in many countries to maximize income and ignore non-revenue-producing activities. In those circumstances, the gathering of data about the physical, chemical and biological environment was seen as an "exotic" science, to be practiced by academics on shoe-string budgets.

Even where the importance of data is recognized, the systems of information transfer do not always work. The use of pesticides is a good example. The laws of the United States make it possible to produce for export chemicals which are banned for use in this country. The United States Department of Agriculture and the Food and Drug Administration recognize the potential dangers of this situation. They also know that some of the crops to which these chemicals are applied are exported back to the United States. They have therefore instituted a policy of informing foreign countries of the reasons for the United States ban. However, this information transfer is both costly and time consuming. Thus, only the most critical data is actually transmitted (Ware, 1979).

A final aspect of the data problem is that what data exists is distributed among several agencies. In Trinidad, for example, rainfall is measured by the Meteorological Service, stream flow by the Water Resources Agency, and stream quality by the Water and Sewerage Authority. The designer of an outfall must therefore determine what data, if any, is available, and who has it. This sometimes requires great enterprise, since extant data must often be sought in unlikely places.

As with the lack of trained personnel, the unavailability of baseline data dictates the use of only basic methodologies at the present time. In countries who have frequently complained of being the dumping ground for worn-out technology, great maturity will be required to accept this situation. Use of more advanced methodologies would require the input of extrapolated or coined data, and the employment of foreign technologists. The former would yield questionable results, and the latter may result in insensitivity to local mores and conventions. Thus the preferable courses would be use of simpler methodologies at present, while at the same time working to eliminate the problems of limited expertise and lack of data.

Social Factors

In every country, industrialized or developing, social factors affect the work of the EIA technologist. Factors such as public participation, cultural diversity, and EIA skepticism must be recognized if plans are to be accepted by the population at large. In the United States of America public participation has been a very useful part of the EIA process (Canter, 1977; and Erickson, 1979). In developing countries public participation in decision-making is a new and often radical-sounding idea. There are several reasons for this. One is that colonial societies were based on the imposition of government from above. Only the views of a selected elite were considered. The masses were ignored. Secondly, most of the population of many developing countries is economically very passive. Thus, practically all initiative comes from above (Engelmann, 1981). It is therefore not surprising that the majority of developing-country citizens are prepared to leave planning to experts. Public participation must therefore be actively sought, not passively awaited. To aid in this, the output of the assessment methodology must be readily understood by the general population. The use of graphic aids and visual presentations is particularly desirable.

There is cultural diversity in many developing countries. This results from the fact that the boundaries of many of these countries were drawn in Europe without regard for pre-existing native arrangements (U.S. Department of State, 1981). In addition, large-scale transplantation of peoples was also practiced by many colonial powers (Carr-Saunders, 1936). The Biafran conflict in Nigeria and the on-going struggle in the Horn of Africa are ample evidence that tribal affilitations supercede imposed national boundaries. The continuing racial division in Trinidad and Tobago and Guyana are clear evidence that even transplanted peoples will try to maintain their cultural heritage. As a result of these factors, many third world countries contain multiple cultural blocks. In situations such as those described above, it is important that the assessor of environmental impacts take careful note of the diverse cultural backgrounds which may be represented, and the potential project impacts on the life styles of various cultural groups. Methodologies oriented toward the cultural attributes within the area of influence of a project should be utilized or adapted as necessary.

The final social factor is related to skepticism of the objectives of EIA. There is a school of thought that it is in the best interest of the industrialized world to keep the third world underdeveloped (Chizea, 1976a and b). Many consider the population program of the past decade as a roadblock to impede the development of the third world. Similarly, present emphasis on environmental protection is considered an excuse to block important development projects. For example, it has been stated that attitudes to EIA in the English-speaking Caribbean range from mild ambivalence to open hostility (Williams, 1981). It is beyond the scope of this report to verify or negate these assertions, but it is important to recognize that these views exist.

In a situation where the skepticism just mentioned is widespread, the use of impact assessment methodologies must be carefully considered. Use of EIA as a tool to approve or disapprove of projects must be de-emphasized. Instead, the benefits of using EIA to identify the best of several alternatives, and to predict impacts in order to plan mitigation measures, should be promoted.

Summary of Special Characteristics

Table III.2 summarizes the effect of special third world characteristics relative to EIA methodologies. Key points in this chapter are summarized as follows:

a. A list of developed countries was developed for use in this study. The classification of 184 political units as developing or industrialized was based upon social, economic, and political indicators; and upon five previous classifications. The geographical distribution of the industrialized and developing countries is as follows. In Africa and the Middle East, 67 countries are classified as developing and only one, Israel, is industrialized. In the Americas, only Canada and the USA are classified as industrialized. In Asia and the Pacific, 5 countries are industrialized and 37 are developing. However, in Europe only 6 of the 31 countries are considered developing. The vast majority of the developing countries lie south of the Tropic of Cancer. Further, the bulk of the industrialized nations are situated in Europe and North America.

b. Because basic needs are as yet unsatisfied in many third world countries, and because of skepticism which may exist, EIA in the third world should be aimed at choosing best alternatives and planning mitigation of detrimental effects. The action/no action choice is often not applicable.

c. In the past, unforeseen detrimental effects of projects have outweighed desired benefits. Use of EIA to predict impacts generally, and health effects specifically, can prevent this from happening again.

d. Because of limited technologists and environmental background data only simple EIA methodologies are usable in the third world at present. However, while accepting this limitation for now, these countries should press on to develop the expertise and data bases required to use more complex methodologies.

e. Particularly when choosing between alternatives, the numerical values used in methodologies developed in industrialized countries will have to be adapted to reflect the values and conditions in the third world.

f. The output of the chosen assessment methodology should be designed to enhance public participation.

Table III.2: Selected Characteristics of Third World Nations Relative to EIA Methodologies (Sammy and Canter, 1982)

	Influence on Selection of EIA Methodologies	
Problem	Category of Methodology*	Comments on Selection
Unfilied basic human needs	SPA	Adjust methodologies to reflect importance of socio-economic factors.
Project magnitude (relatively large projects)	II, IPA, SPA	Use methodologies which are comprehensive, predict the magnitude of potential impacts, and permit direct comparison between alternatives.
Scarcity of trained personnel	II, DAE, IPA, SPA	Use methodologies with minimal requirements for trained personnel.
Lack of environmental baseline data	DAE, IPA, SPA	Use methodologies with minimal baseline data inputs.
Public participation	SPA	Use methodologies with good display of results.
Cultural diversity	II, DAE, IPA, SPA	Use methodologies which focus on cultural features and impacts.

* II = impact identification; DAE = description of affected environment; IPA = impact prediction and assessment; SPA = selection of proposed action.

CHAPTER IV

EIA METHODOLOGIES

It was noted in Chapter II that many methodologies have been devised to facilitate the steps involved in conducting an environmental study. In this chapter, examples of these methodologies will be discussed. The first section is devoted to defining some of the terms used in the chapter. The next section introduces the various types of methodologies which are available. The final two sections are devoted to the use (or application) of methodologies, and some of their attributes. This chapter lays the groundwork for evaluation of specific assessment methods and prediction techniques which may be applicable in developing countries. The actual review and evaluation of these systems will be done in Chapters VII and VIII.

One misconception about EIA methodologies which has gained wide acceptance is the idea that only one methodology is sufficient to conduct an assessment. This is not so. A satisfactory environmental study requires the application of several techniques and methods, and these may be based on the different methodologies. In the assessment of a very large project, each step may require the use of several techniques.

Terminology

In environmental literature, the term methodology is used frequently, and at times loosely. In some cases, "methodology", "method", "system" and "technique" are all used interchangably. For clarity, it is necessary to explain these terms as they are used in this chapter. As used herein, the generic term methodology refers to a structured or systematic approach to accomplishing one or several of the steps in EIA (Sammy and Canter, 1982; Webster's New Collegiate Dictionary, 1975). The terms method, system and technique are all used synonymously to denote specific adaptations or applications of methodologies. The difference can be further clarified with the following examples.

The Battelle Environmental Evaluation System (EES) is a method from the Weighting-Scaling Checklist methodology. All of the general principles which are used in constructing any weighting-scaling checklist make up the methodology. These include the assignment of weights to account for the relative importance of items on the list, and the development of scaling a function for each item.

Similarly, the Streeter-Phelps equation comes under the general methodology of mathematical modeling. This methodology uses mathematical equations to represent physical phenomena. The equations themselves may be relatively simple or quite complicated. However, they are based on an understanding of the driving forces of the phenomena being modeled. Streeter and Phelps applied this methodology to the depletion and recovery of oxygen in a body of water, and derived the equation which bears their name. While the basic principles of mathematical modeling are a methodology, the specific equation is a method.

The final example is the methodology involving matrices. The general principle is that the interaction of actions and consequences can be conveniently displayed as a matrix. Actions are listed on one axis, and environmental items on the other. The importance and/or magnitude of each impact resulting from each action can be indicated at the appropriate node by a color, letter or number code. This, in essence, is the methodology. The specific method is, for example, the Leopold Interaction Matrix. There are others.

In summary, therefore, a methodology is a set of principles which define a general but systematic approach to accomplishing one of the steps in an EIA. By their nature, methodologies are generic. The terms methods, systems and techniques are used synonymously. They refer to tools for performing particular tasks in the environmental study. Each of these tools is based upon the principles of a methodology. However, they are specific in application.

Purely for convenience, the methods, systems and techniques which can be used in environmental studies are divided into two groups in this report. The term "assessment methods" is used to describe those which are used for impact identification, baseline studies and comparison of alternatives. These are the newer methods, and were developed specifically for use in environmental impact studies. It should be noted that very few techniques have been developed for use only in the baseline study. Many of the techniques which are used in this step are also useful in identifying and predicting impacts. A review of specific assessment methods will be undertaken in Chapter VII.

The term "prediction techniques" is used to signify approaches to quantify project effects. The planning of mitigation measures is based upon these predictions. Predicting the magnitude and interpreting the importance of impacts is the most important technical aspect of an assessment. Many of the techniques and models used pre-date the environmental era. These involve many fields of the physical, biological and social sciences. A limited review of these prediction techniques is undertaken in Chapter VIII. The objective of that review is to familiarize the reader with the application of these techniques, the input data requirements, and any special tools (such as a computer) which may be needed. The reader who wishes to actually use a technique will need to refer to the cited source.

Types of Methodologies

The two most frequently used EIA methodologies are matrices and checklists. The former may be simple or stepped. The latter can be simple, descriptive, scaling, ranking, weighting/scaling or weighting/ranking. Other methodologies include networks, mathematical models, statistical models, empirical indices, overlays, structured habitat approaches and cost-benefit analysis. This section is devoted to introducing each of these methodologies.

Matrices

An EIA matrix is basically a two dimensional chart listing project activities on one axis and environmental parameters on the other. When a particular activity is expected to affect a parameter, this is indicated by a notation at the appropriate intersection point. Figure IV.1 shows a simplified matrix based on the Arena Dam of the Caroni-Arena Water Supply Project in Trinidad (Trintoplan, 1976). It must be stressed that this is a very simplified matrix, presented for illustration only.

In Figure IV.1, the interaction between activity and parameter is shown as an "X". No attempt is made to identify whether the impact is beneficial or adverse. A first improvement would therefore be to replace the "X" with "+" or "-" signs to indicate beneficial and adverse impacts, respectively. In this case, for example, the forest clearing/air, earthwork/housing, and emergency drawdown/flooding interactions would all be rated "-" since they represent adverse effects. Forest clearing releases particulates into the air, the influx of heavy equipment operators for earthwork causes a housing shortage in the project area, and the area just downstream of the dam will be flooded if emergency drawdown ever becomes necessary. On the other hand, other construction/employment, wet season impoundment/flooding, and dry season release/health would be rated "+" since they are beneficial impacts. The construction phase of the project generally increases employment, wet season impoundment reduces seasonal flooding downstream of the dam, and the dry season releases improve

Environmental Parameters	Project Activities					
	During Construction			During Operation		
	Forest Clearing	Earth -Work	Other Construction	Wet Season Impoundment	Dry Season Release	Emergency Drawdown
<u>Physical-Chemical:</u>						
Air		X				
Water	X	X		X	X	
Soil	X	X				
<u>Biological:</u>						
Fisheries				X	X	X
Flora	X					X
Birds	X					X
Animals	X					X
<u>Socio-Economic:</u>						
Employment	X	X	X	X	X	
Housing	X	X	X			
Health	X	X	X	X	X	
Flooding	X			X		X

Figure IV.1: Simplified Matrix for a Dam Project (Based on the Caroni-Arena Water Supply Project, Trinidad, West Indies).

health by supplying adequate quantities of water to be treated for domestic supply.

A further refinement would involve rating the magnitude and/or importance of the impacts on a numerical scale. In this context, magnitude indicates the degree by which a parameter changes, and importance addresses the significance to the area and population affected. Again referring to Figure IV.1, the employment impacts are of varying magnitude. Those occurring during construction are of large magnitude, since many jobs are created. Those occurring during operation are of low magnitude, since only a few jobs are created. The health effects demonstrate differences in importance. The construction health effects are limited to the immediate area of the project. They are therefore of minor importance. During the wet season, the impounded lake may become a breeding-ground for mosquitos. This would be an adverse effect of moderate importance, because the effects of these pests will be felt beyond the immediate project area. The provision of safe water to a majority of Trinidad during the dry season would be a benefit of great importance. This concept of numerically rating the magnitude and importance of interactions is used in the Leopold Matrix, which will be discussed in detail in Chapter VII.

Stepped matrices attempt to expand the scope of analysis to include indirect or secondary effects.

Both simple and stepped matrices are useful in baseline studies, impact identification and evaluation, planning mitigation measures, and assessment and comparison of alternatives. The list of environmental parameters is a good guide to the topics to be included in the description of the affected environment. The matrix format enhances the identification and evaluation of impacts in a systematic manner. The list of adverse impacts identified is a first step to the planning of mitigation measures. Finally, comparisons can be facilitated by developing a matrix for each alternative (Canter, 1981b; Lohani and Arceivala, 1982; and Evans, 1982).

Checklists

Like matrices, checklists were among the earliest methodologies used to assess environmental impacts. Currently, there is a wide variety of checklist formats available, and a host of adaptations of each format to specific projects. The most basic format is a simple checklist. This consists of a list of environmental factors which should be addressed in the course of the assessment. It is most often based on experiences on other similar projects. As a result, simple checklists are sometimes specific to a given type of project. An example of a simple checklist is shown in Figure IV.2(a). Again, it must be emphasized that this example is presented for illustration only. It is by no means as complex as an actual assessment of this project would be.

Simple checklists do not provide information as to specific data needs and methods of measurement; or impact prediction, quantification and evaluation. Descriptive checklists do address these items, as can be seen in Figure IV.2(b). The predicted impacts can be listed in appropriate units for each project alternative, including the

a) Simple Checklist:

Impacts	Stage of Project		
	Planning & Design	Construction	Operation
Noise		X	X
Air Pollution		X	X
Water Quality		X	
Economic Impacts	X	X	X

b) Descriptive Checklist:

Impacts and Units	Stage of Project	Alternative		
		A	B	C
NOISE: measured at school in adjacent village (dBA)	a) Construction b) Operation			
AIR POLLUTION: Carbon Monoxide levels during atmospheric inversion (ppm)	a) Construction b) Operation			
WATER QUALITY: Suspended Solids in Caroni River (mg/l)	a) Construction			
ECONOMIC EFFECTS:				
(i) Land Speculation ($/acre)	a) Design			
(ii) Loss of agricultural land (acres)	a) Construction b) Operation			

Figure IV.2: Simplified Checklists for a Highway Expansion (Based on Princess Margaret Highway Expansion, Trinidad, West Indies).

no-action alternative. Based on this tabulation, an ad hoc comparison of alternatives is possible.

The next refinement of the checklist methodology involves the use of ranking or scaling to permit systematic comparison of alternatives. Ranking involves arranging the alternatives in order of preference. This is based on the predicted magnitude of effects. In the example in Figure IV.2(b), this would be done as follows. The alternative generating the least noise during construction will be ranked 1, the next 2, and so on until the noisiest alternative receives the highest rank. This is repeated for each impact in the checklist. Care must be taken to ensure that the ranking is in order of desirability; the most desirable alternative being ranked first.

Scaling is the assignment of a score to each alternative, based on the anticipated magnitude of the impact. This is commonly done in terms of quality indices, an example of which is given in Figure IV.3. Scaling is preferable to ranking in some cases, since it reflects the actual magnitude of the impact. Ranking simply indicates the order of desirability. Consider, for example, a bridge over a stream with a natural suspended solids concentration of 5 mg/l. Three alternatives are no bridge, suspension bridge and multispan bridge. These would be ranked and scaled (see Figure IV.3) during construction as follows:

Alternative	No Bridge	Suspension	Multispan
Suspended solids (mg/l)	5	8	25
Rank	1	2	3
Scale	.95	.90	.25

It can readily be seen that the scaling numbers show a more representative picture than do the ranks. There are, however, cases

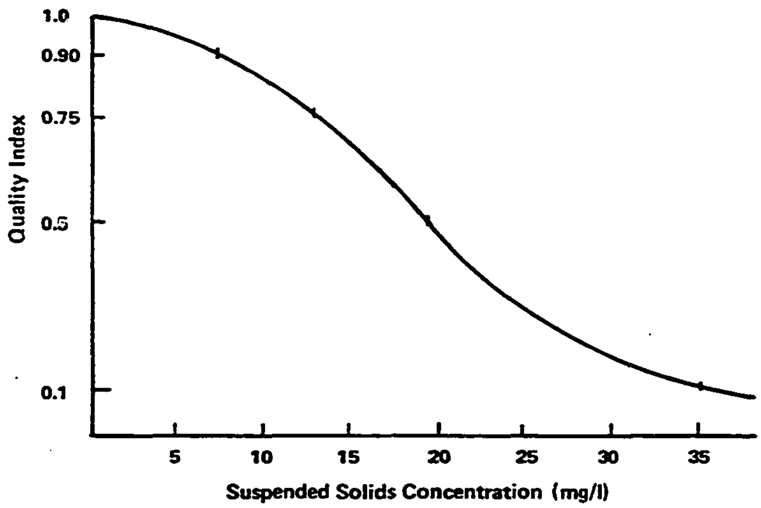


Figure IV.3: Scaling Function for Suspended Solids Concentration (Canter and Hill, 1979) where ranking is more appropriate than scaling. These are where the scaling function cannot be easily formulated or where quantitative data is not available. Examples include intangibles like aesthetics.

The use of scaling and ranking checklists to compare alternatives tends to ignore the relative weights of impacts. It is a fact that some impacts are more important than others. Refering to Figure IV.2, for example, it will be appreciated that noise during construction would be less important than long-term loss of agricultural land in choosing the best alternative. It is possible to take these differences in importance into account by using weighting-ranking or weighting-scaling checklists. In these techniques, a relative weight is assigned to each impact on the checklist. The composite of the impacts of each alternative is then computed by summing the products of importance weight by scale (or rank) for all impacts. One of the best-known EIA systems, the Battelle Environmental Evaluation System, is a weighting-scaling checklist. This will be discussed in greater detail in Chapter VII.

Checklists can assist in baseline studies, impact identification and evaluation, planning mitigation measures, and assessment and comparison of alternatives. Simple and descriptive checklists can be used for baseline studies and impact identification. Descriptive, scaling or ranking checklists can aid in impact evaluation and planning mitigation. Weighting-ranking and weighting-scaling checklists are particularly useful in comparing alternatives (Canter, 1977; and Lohani and Arceivala, 1982).

Networks

Networks use links and nodes to depict the interrelationship between project activities and environmental impacts, including secondary and higher order effects. They have been used on dredging projects and highway developments among others. The actual form of the network can be either a tree or a web. Energy system diagrams are a specialized form of network which have found limited application in EIA. The major drawback of networks is that they can become unmanagably complex. However, with enough time and effort, networks can be simplified and organized to permit meaningful analysis and recommendations (Erickson, 1979). When this is done, networks are particularly useful in identifying impacts. They can also aid in describing the affected environment (Canter, 1977; and Sammy and Canter, 1982).

Mathematical Models

The most important technical step in preparing an EIA is the quantification of impacts. This involves calculation of the magnitude of anticipated changes, both beneficial and adverse. Every effort should be made to ensure use of the best available scientific methods in this step, since more accurate predictions will result in greater confidence in the overall assessment. Foremost among the methods available to predict the magnitude of impacts are mathematical models, many of which predate the environmental era.

Mathematical models are based on theoretically established or experimentally determined patterns of natural phenomena. They have been used to quantify air, noise, and surface water pollution; ground water flow; some biological changes; and certain socio-economic impacts. Examples of phenomena which have been modeled mathematically include:

- Plume dispersion (Crawford, 1976),
- Sound propagation in enclosed space (Lord, Gatley and Evensen, 1980),
- The oxygen sag curve (Metcalf and Eddy, Inc., 1972),
- Ground water drawdown due to pumping of wells (Bouwer, 1978),
- The eutrophication process (Middlebrooks, Falkenberg and Maloney, 1974),
- Cost-Demand functions (d'Arge, 1981, and Commoner, 1981).

Mathematical models, by their nature, are most useful in quantifying impacts and in planning mitigation. Because of the numerous and diverse areas where mathematical models can be applied, a thorough listing and discussion of available models is beyond the scope of this report. During the course of an actual assessment, it is likely that specialist input will be required to conduct this step. After likely impacts have been identified, technologists with competence in specific areas must quantify and evaluate changes and plan mitigation measures. Their results can then be used to assess and compare alternatives.

Statistical Models

Statistical models are a sub-set of mathematical models. They are listed separately because of their importance. These models are most useful where data has been collected on a particular phenomenon, but the phenomenon has not been theoretically defined by mathematical equations. One important difference between the mathematical models described previously and statistical models is that the former are generalized, while the latter are site- and application-specific. Statistical models have been applied to pollutant transport in air, surface water, ground water and the marine environment. They have also been used to study population growth, economic expansion, and other socio-economic phenomena. Like other mathematical models, statistical models can be used to predict the magnitude of environmental changes, thus forming the basis for evaluating the significance of these changes and planning mitigation measures.

Empirical Indices

These techniques involve simple numerical approaches to describing baseline conditions and to comparing the pollution potential of alternative actions (Ott, 1978). They are generally based on the rating of prescribed factors by the application of environmental index functions. Several empirical index techniques have been developed to rate the potential for ground water pollution from sources such as wastewater ponds, landfills, etc. One of these, the modified LeGrand Method, is summarized in Table IV.1. The main advantage of these index methods is that they use secondary data (i.e., data gathered primarily for other uses). Thus, they can be very useful when time or budgetary constraints preclude the development and application of mathematical or statistical models.

Table IV.1: Summary of Modified Le Grand Method (U.S. Environmental Protection Agency, 1978)

STEP	FACTOR	RATING SCALE	BASIS OF RATING
STEP 1:	Rate the Unsaturated Zone	0 to 9	Earth material type and representative permeability
STEP 2:	Rate the Ground Water Availability	0 to 6	Aquifer material type and representative permeability
STEP 3:	Rate the Ground Water Quality	0 to 5	Total dissolved solids in water and aquifer use
STEP 4:	Rate the Waste Hazard Potential	0 to 9	Contaminant type and Standard Industrial Classification (SIC) of source
STEP 5:	Calculate the Overall Ground Water Contamination Potential (= Step 1 + Step 2 + Step 3 + Step 4)		

Overlays

Overlays are transparent sheets showing specific data which can be placed on base maps to identify potential areas of conflict. This technique has been used in architectural design, and more recently in highway route selection (Lohani and Arceivala, 1982). In general, the base map is a standard topographic sheet for the project area. Overlay sheets are produced to show areas of special environmental interest, such as archeological sites, fragile habitats, scenic vistas, etc. One transparency is then produced to show each project alternative. By overlaying combinations of these sheets, it is possible to visually identify areas of conflict. This in turn aids in comparison of alternatives and planning mitigating measures. The preparation of the base map and overlays often dictates the extent of the baseline study. Once conflicts have been identified, their magnitude and importance can be investigated using other methods such as matrices (Bell, Detre and Smedley, 1979). One recent development in overlays has been their adaptation to computer graphics. Here, the computer is programmed to superimpose specific new data onto an existing map.

Structured Habitat Approaches

The prediction of biological impacts can be facilitated by the use of structured habitat approaches. These systems are based on habitat types and features and indicator species of flora and fauna. These approaches can also be used to compare the effects of various project alternatives upon the biological environment. Two examples of this type of assessment system are the Habitat Evaluation Procedure and the Habitat Evaluation System. The latter will be discussed in Chapter VII.

Cost-Benefit Analysis

The cost-benefit analysis methodology has been applied to engineering projects for many years. However, the inclusion of environmental aspects in the analysis is relatively recent. Evans (1982) has commented that the use of cost-benefit analysis to conduct environmental analyses would be ideal, since this is a "language" that decision-makers already understand. However, there is one major drawback to this approach: the assignment of dollar values to basically intangible costs and benefits. What, for example, is the cost of the loss of a scenic vista? What is the dollar benefit of increased life expectancy? The lack of definitive answers to such questions has been, and continues to be, a stumbling block to the widespread use of cost-benefit analysis in environmental impact assessment (Commoner, 1981; and d'Arge, 1981). However, the approach is valid when all parties agree that the proposed project will have no environmental impacts. It is also valid when all alternatives being considered will have identical impacts upon the environment (Bell, Detre and Smedley, 1979). Another means of avoiding the problem of assigning dolar values to costs and benefits is to use another set of common units. For example, cost-benefit analyses can be conducted by expressing impacts in terms of energy requirements and production.

Summary

This section has dealt with the various methodologies available for use in performing the various steps in an environmental assessment. The potential application of these methodologies to each of the steps in an assessment is shown in Table IV.2. The next section deals with the use to which methodologies have actually been put in environmental studies to date.

Use of Methodologies

The complaint has been voiced that, despite the number and diversity of assessment methodologies now available, many environmental studies are still conducted on an ad hoc basis (Erickson, 1979). In the next few paragraphs, three studies of methodology use will be considered. These are by Canter (1979a), Environmental Resources Ltd. (1981a, b and c), and Petts and Hills (1982).

Wastewater Treatment Plants Study

Canter (1979a) reviewed environmental impact statements prepared for 28 municipal wastewater treatment plants in the United States of America. The overall approach to the environmental study was discussed in each case, specific attention being paid to the choice of alternatives. A summary of methodologies used to compare alternatives is found in Table IV.3. Eight of the assessments used no formalized procedure for comparison. The remaining 20 all used checklists. Of these, 4 were descriptive, 10 were scaling or ranking, and 6 were weighting-scaling or weighting-ranking.

Table IV.2: Applications of Methodologies in EIA Process

METHODOLOGY	STEP IN ASSESSMENT PROCESS					
	BASELINE STUDY	IMPACT IDENTIFICATION	IMPACT QUANTIFICATION	IMPACT EVALUATION	MITIGATION PLANNING	COMPARISON OF ALTERNATIVES
MATRICES:						
a) Simple	(X)	X			(X)	X
b) Stepped	(X)	X		X	(X)	X
CHECKLISTS:						
a) Simple	X	X				
b) Descriptive	X	X		(X)	X	
c) Ranking	X	X		(X)	X	(X)
d) Scaling	X	X		(X)	X	(X)
e) Weighting-Ranking	X	X		(X)	X	X
f) Weighting-Scaling	X	X		(X)	X	X
NETWORKS	X	X				
MATHEMATICAL MODELS			X	X	X	
STATISTICAL MODELS			X	X	X	
EMPIRICAL INDICES				(X)	(X)	X
OVERLAYS	(X)	X			X	X
STRUCTURED HABITAT APPROACHES	X		(X)		X	X
COST-BENEFIT ANALYSIS						X

<u>Notes:</u> [1](X) = limited application
[2] X = general application

Table IV.3: Methodologies Used to Select Alternatives for 28 Wastewater Treatment Plants (Canter, 1979a)

METHODOLOGY	NO. OF TIMES USED
CHECKLISTS:	
Ranking	4
Scaling	6
Weighting-Ranking	1
Weighting-Scaling	5
Descriptive	4
AD HOC PROCEDURE:	8

Assessments from 17 Countries

Environmental Resources Ltd. (ERL) (1981 a, b and c) studied 138 assessments of many types of projects from 17 different countries. Roughly 37% of these were from the United States and 21% from the United Kingdom. The majority of the remainder came from Canada, Australia and Europe. The report concentrates on techniques used to identify, and in some cases quantify, environmental impacts. The results pertaining to 98 projects are presented in Table IV.4. Methods of impact identification and prediction are categorized into qualitative descriptions, expert judgment, direct evaluation and structured techniques. Qualitative descriptions are a non-quantified listing of the likely impacts of each alternative. Expert judgments are a listing of the estimates of the magnitude of impacts. These estimates are made by an expert in the relevant field, based on previous observations on other projects and on an understanding of the project and affected environment. Direct evaluation is a consideration of the relative significance of the effects of alternatives. It is a ranking procedure. Structured techniques involve the use of an explicit, pre-defined relationship (model) to predict and quantify the effects of project alternatives. Structured techniques are further subdivided into modeling and survey techniques. The former involves the use of mathematical or statistical models. The latter is the collection of baseline data either to show the importance of loss or changes, or to indicate the environment's sensitivity to changes. From the table, it can be seen that the use of qualitative description and expert judgment predominates. Even in fields where models are

Table IV.4: Assessment Methods Used in 98 EIAs from 17 Countries (Environmental Resources Ltd., 1981b)

	Number of times the effect is considered in all case studies	Qualitative Description	Expert Judgement	Direct Evaluation	Structured Techniques			
					No. of examples of use of techniques			Estimate of No. of different techniques
					Modelling	Survey	Total	
Prediction of Sources:								
Emissions to air	31	8	9	1	13	-	13	8
Discharges to water	11	7	2		2	-	2	2
Emissions of sound	10	1	4	1	4	-	4	2
Quantities of waste	3	1		1	1	-	1	1
Release of substances	0	-	-	-	-	-	-	-
Release of radio-activity	3				3	-	3	2
Physical characteristics	12				2	10	12	6
Accidents	8	3		1	4	-	4	4
Natural disasters	7	3	2		1	1	2	2
Use of resources	4	1	1	1	1	-	1	1
Prediction of Effects on:								
Soil	13	6	3	2	2	-	2	2
Landform	30	13	6	4	3	4	7	6
Hydrological	53	25	7	3	15	3	18	9
Climate	5	3	1		1	-	1	1
Air quality	63	20	8	2	32	1	33	18
Water quality	114	50	30	10	19	5	24	12
Noise environment	56	11	13	6	26	-	26	17
Visual environment	64	24	2	11	11	16	27	2
Landscape ecology	3				-	3	3	1
Recreation	25	5	1	9	-	10	10	2
History and Culture	27	16		4	-	7	7	2
Scientific and natural resources	12	4	1		-	7	7	2
Local amenity	46	14	1	10	4	17	21	5
Plants and Animals	186	108	31	18	5	24	29	4
Agriculture	41	14	3	7	-	17	17	2
Forestry	22	2		6	-	14	14	3
Fisheries	29	20	4	4	-	1	1	1
Minerals	5	2		1	-	2	2	2
Water Resources	7	2	4		-	1	1	1
Property	14		2	1	-	11	11	2
Public Health and Safety	56	16	7	17	5	7	12	5

available and well-established, such as water quality, the tendency was to use qualitative rather than quantitative methods.

The trend noted in the last paragraph is not a desirable one. Impact prediction is the single most important technical activity in an assessment. Based on these predictions, mitigation measures are planned and the proposed action is selected. Thus, the accuracy of impact prediction is pivotal to the success of the overall assessment. For this reason, every effort should be made to ensure that state-of-the-art methods are used to compute expected environmental changes resulting from impacts. Naturally, the actual methods used will be dictated by the area in which the project is located. For example, it would be impossible to develop a statistically-based air pollution dispersion model for a rural area where there are no climatic records available. However, given the limitations of the specific study area, the prediction techniques used should be those which yield the most accurate and dependable results.

Table IV.5 presents more detail on the prediction techniques used in the assessments studied by ERL. In some cases, ERL's report identified the specific method employed, such as flow hydrographs, the universal soil loss equation, etc. In other cases, only the general methodology was identified. These included mathematical models, overlays, etc. The report also listed several survey techniques that were used to identify, but not quantify, impacts. These were not included in Table IV.5.

This study shows that there are many techniques available for predicting a very diverse set of impacts. Those presented are by no

Table IV.5: Impact Prediction Techniques Used in 98 EIA from 17 Countries (Environmental Resources, Ltd., 1981c)

Parameter Predicted	Techniques Used
Air	
a. Emission rates of SO_2, NO_x, sulfur, particulates, etc.	1. Emission factors from industrial plants 2. Emission factors from vehicles 3. Combustion rate calculations
b. Resulting concentrations of SO_2, NO_x, CO, particulates, etc.	1. Dispersion models 2. Diffusion models 3. Empirical equations 4. Computerized models 5. Statistical models
c. Climate	1. Statistical models
Water	
a. Emission of pollutants to surface and ground waters.	1. Emission factors from industrial plants 2. Simple model of the leaching process
b. Effects of project on surface and ground waters	1. Moisture balance equation 2. Mathematical models 3. Physical scale models 4. Radial flow equations 5. Computerized models 6. Statistical models 7. Empirical equations (the Rational Method) 8. Flow Hydrographs
Soil	
a. Effects of pollutant discharges	1. Soil moisture balance equations 2. Heavy metal accumulation, based on first principles
b. Effects of project on land form	1. Sediment transport model (marine) 2. Physical scale model 3. Universal Soil Loss Equation
Sound	
a. Noise emissions	1. Emission factors for transport systems.
b. Resulting noise levels	1. Mathematical models 2. Computerized models 3. Noise rating index 4. Standard scales plus overlays
Radioactivity	
a. Frequency of discharge	1. Calculated from radioactive fuel use rate
b. Levels of radioactivity released	1. Mathematical models
Land Use	
a. Required area for Project	1. Unit area calculations 2. Topographic surveys
Aesthetics	
a. Visual Impacts	1. Sketches 2. Photomontages 3. Rating techniques 4. Overlays and maps 5. Equations relating visibility to air pollution
b. Landscape	1. Index (rating) techniques
Recreation	
a. Recreational areas lost	1. Index (rating) techniques
Biological Systems	
a. Herd size reduction	1. Calculation based on area of habitat lost
b. Toxicity and bioaccumulation of pollutants	1. Bioassay (laboratory experiments) 2. Rating (index) techniques
c. Agriculture and Forestry	1. Index techniques
Economics	
a. Effects on resources, property, etc.	1. Index techniques 2. Assignment of dollar values to lost resources or property (cost/benefit)
Public Health and Safety	1. Mathematical models 2. Index technique

means a complete list. Among the areas not included are socio-economics and culture. Methods of predicting impacts are available in both these areas. The use of techniques such as those listed in Table IV.5 will improve the quality of environmental studies and result in more readily justifiable choices of alternatives.

Miscellaneous Studies from the United Kingdom

Petts and Hills (1982) summarized 154 environmental studies on a variety of projects in the United Kingdom. A capsulized summary of each study was presented. In the majority of cases, baseline studies were conducted. Models were used to compute the magnitude of impacts of each alternative in about half of the EIAs. The actual techniques used to predict impacts were not listed. However, environmental parameters for which impacts were quantified were identified. These are listed in Table IV.6. These parameters came from each aspect of the overall environment. In the physical-chemical environment, air and noise impacts were evaluated most often. Impacts on the biological environment were computed based on construction and operating activities, and also based on catastrophic incidents. Particular concern was expressed about the effects of off-shore oil and gas field accidents on marine life. Of impacts on the socio-economic environment, economic effects were addressed most often. These included changes in the rate of unemployment, average income, land values, etc. Cultural impacts which were evaluated related mainly to aesthetics.

Table IV.6: Impacts Evaluated in 154 Environmental Studies (Petts and Hills, 1982)

A. CONSTRUCTION AND OPERATING IMPACTS			66 Studies *
ENVIRONMENT	PARAMETER	# OF TIMES ADDRESSED	
Physical-Chemical	Air	22	
	Water	9	
	Noise	29	
	Other Physical-Chemical	3	
Biological		14	
Socio-Economic	Economic	26	
	Health	3	
	Other Social	7	
Cultural	Aesthetic	19	
	Archeological	3	
	Other Cultural	2	
B. CATASTROPHIC IMPACTS (RISK ANALYSIS)			16 Studies *
C. IMPACTS NOT QUANTIFIED OR PREDICTIONS NOT STATED			80 Studies *

* A, B and C do not sum to 154, because there is some overlap between A and B.

The conclusions concerning impact prediction from this study are the same as those drawn from the ERL study. First, it is noteworthy that in just over half of the EIAs studied the prediction of impacts is not addressed. This implies either that impacts were not quantified, or that the results of the prediction were not listed. There were a few cases where the subject of the EIA was very general. Here, detailed calculation of environmental changes would be inappropriate. However, there were many other instances where these calculations could and should have been done.

The second conclusion about impact prediction is that techniques are available to compute impacts from all spheres of the environment. The use of these techniques is limited by several constraints: input data, financial resources and technical expertise. However, within these constraints, the use of structured techniques instead of ad hoc approaches or expert judgment enhances the quality of the overall assessment.

In about a quarter of the EIAs studied by Petts and Hills, the methods used to compare alternatives and choose the preferred action were indicated (see Table IV.7). In the majority of cases, no structured approach was identified. Where these were used, matrices and checklists were most common, followed by overlays, cost-benefit analysis, networks and empirical indices in that order. The use of structured approaches to compare alternatives is highly desirable for several reasons. The results of such approaches are reproducible, and the comparison is objective. This means that the technologist doing the comparison is less susceptible to political or other pressures.

Table IV.7: Methodologies Used to Select Alternatives for 154 Projects in the United Kingdom (Petts and Hills, 1982)

METHODOLOGY	NO. OF TIMES USED
MATRIX:	11
CHECKLIST:	
Simple	2
Descriptive	4
Ranking	1
Weighting-Scaling	1
NETWORK:	1
EMPIRICAL INDEX:	1
OVERLAY:	4
COST-BENEFIT ANALYSIS:	3
NOT STATED:	116

Also, the end product can more easily be explained and justified if the approach is a logical one. Finally, there is less likelihood of considerations being ignored in a structured approach.

Conclusions from Previous Studies

This section has consisted of a review of three studies which together presented an inventory of 320 EIAs from 17 countries. Two general conclusions can be drawn. The first is that there are several systematic methods available to assist in identifying impacts and comparing alternatives. In the past, many EIA's have omitted the use of these methods, relying instead upon "expert opinion". The use of systematic methods to identify impacts reduces the probability of inadvertently ignoring important effects. When alternatives are compared systematically, the proposed action is more easily defensible, and less prone to charges that it is a "fixed" choice.

The second conclusion is similar, but relates to prediction techniques. Many techniques are available for predicting changes in different environmental parameters. To date, a significant proportion of EIA's have been conducted without the use of these techniques. Instead, survey techniques and "expert judgment" have been used to qualitatively address impacts. In many cases, the use of techniques would have improved the quality of the environmental study. The importance of prediction techniques derives from the fact that the quantification of impacts is the single most important technical task in conducting an EIA. The assessment of impacts, the planning of mitigation and the comparison of alternatives all depend upon these predictions. Therefore, the techniques used to quantify predictions should be those which yield the most accurate and dependable results.

The next section deals with some of the desirable characteristics of EIA methodologies. Naturally, each methodology has both attributes and limitations. When choosing a method for use in a particular environmental study, certain project-specific criteria must be established. Some of these will coincide with the attributes discussed in the next section.

Attributes of Methodologies

Five comparative studies will be discussed in this section. These were conducted by Warner and Preston in 1973, by Smith in 1974, by Solomon, et al. in 1977, the Waterways Experiment Station (1981), and Colombia's National Institute for Renewable Natural Resources and the Environment (INDERENA, 1981). The first two are contemporaneous with a sixth study by Jain and Urban in 1975. Based on these studies, a list of desirable attributes of environmental assessment methodologies will be developed. The importance of each of these criteria will then be discussed.

Previous Studies

Warner and Preston (1973) listed 23 criteria as a basis for comparison. Under impact identification, the five criteria were comprehensiveness, specificity, isolate project impacts, timing and duration, and data sources. Under impact measurements, three criteria were identified: explicit indicators, magnitude and objective. The seven impact interpretation criteria were significance, explicit criteria, uncertainty, risk, alternatives comparison, aggregation and public involvement. There were five impact communication criteria: affected parties, setting description, summary format, key issues, and NEPA compliance. The last three criteria were related to resource requirements, replicability and flexibility. Table IV.8 lists questions which exemplify each of the 23 criteria.

Smith (1974) used ten criteria. These required that methodologies be comprehensive, be flexible, detect true impact and be objective. They should ensure input of required expertise, utilize the state-of-the-art and employ explicitly defined criteria. Finally, they should assess actual magnitude of impacts, provide for overall assessment of total impacts and pinpoint critical impacts. A fuller explanation of each criterion is given in Table IV.9.

A third comparative study conducted in this same time period was that by Jain and Urban in 1975. Since there is considerable overlap between that study and the work of Warner and Preston (1973), individual discussion of the Jain and Urban work will not be included here. Of the 8 methods identified by Smith and by Warner and Preston as best satisfying the criteria of its respective study, one was a matrix, four were checklists and three were overlays.

Solomon, et al. (1977) used three screenings to evaluate a total of 54 methodologies during the course of developing the Water Resource Assessment Methodology (WRAM). The first screen was to eliminate those methodologies which were inapplicable to water resources projects. Methodologies passed this screen because either (a) they had been previously applied to water resources projects, or

Table IV.8: Criteria for Warner and Preston Study (Warner and Preston, 1973)

Criteria	Questions
Comprehensiveness	Does the methodology address a full range of impacts?
Specificity	Are specific environmental parameters identified?
Isolate project impacts	Does the method suggest ways of identifying project impacts?
Timing and duration	Does the method suggest construction-phase impacts vs. operational-phase impacts?
Data sources	Does the method require identification of data sources?
Explicit indicators	Does the method suggest specific measurable indicators for impact quantification?
Magnitude	Does the method require determination of impact magnitude?
Objectivity	Does the method stress objective rather than subjective measurements?
Significance	Does the method require an assessment of significance on a local, regional, and national scale?
Explicit criteria	Does the method require that the criteria and assumptions in significance determination be stated?
Uncertainty	Does the method address uncertainty or the degree of confidence in impact projections?
Risk	Does the method focus on impacts of low probability of occurrence but high potential damage?
Alternatives comparison	Does the method provide a way of comparing alternatives?
Aggregation	Does the method provide a way for aggregation of information on impact measurement and interpretation?
Public involvement	Does the method provide a way for public input in the interpretation of impact significance?
Affected parties	Does the method link impacts to affected human groups?
Setting description	Does the method require a description of the environmental setting?
Summary format	Does the method contain a suggested summary format?
Key issues	Does the method suggest a way of highlighting key impacts or issues?
NEPA compliance	Does the method focus on NEPA/CEQ requirements?
Resource requirements	Does the method use current data or are special studies required? Are special skills required? How much time is necessary to learn the method? What are the costs of using the method? Are special technologies required?
Replicability	Is the method ambiguous? To what degree will different results occur depending on the analyst?
Flexibility	Does the method apply to projects of different size or scale? Does the method apply to projects of different types? Can the method be applied to different basic environmental settings?

Table IV.9: Criteria for Smith Study (Smith, 1974)

1. Be comprehensive - The environment contains intricate systems of living and nonliving elements bound together by complex interrelationships. An adequate methodology must consider impacts on these systems.

2. Be flexible - Sufficient flexibility must be contained in the methodology, since projects of different size and scale result in different types of impacts.

3. Detect true impact - The actual impact is that change in environmental conditions resulting from a project, as opposed to the change that would naturally occur from oxisting conditions. Moreover, both short-term and long-term changes must be measured.

4. Be objective - The methodology must be objective, providing impersonal, unbiased, and constant measurements immune to outside tampering by political and other external forces. An objective and consistent procedure provides a firm foundation, which can be periodically updated, refined, and modified, thereby incorporating the experience gained through practical application. To be effective as a decision-making tool, environmental impact assessments also must be repeatable by different analysts and able to withstand scrutiny by various interest groups.

5. Ensure input of required expertise - Sound, experienced, professional judgment must be assured by a methodology, especially as subjectivity remains inherent in many aspects of environmental evaluation. Input of the necessary expertise can be achieved either through the design of the methodology itself or through the rules governing its use.

6. Utilize the state of the art - Maximum appropriate use of the state of the art must be made, drawing on the best available analytical techniques.

7. Employ explicitly defined criteria - Evaluation criteria, especially any quantified values, employed to assess the magnitude or importance of environmental impacts should not be arbitraily assigned. The methodology must provide explicitly defined criteria and explicitly stated procedures regarding the use of these criteria, with the rationale behind such criteria documented.

8. Assess actual magnitude of impacts - Means must be provided for an assessment based on specific levels of impact for each environmental concern, in the terms established for describing that concern (e.g., BOD, pH, and temperature for water quality). Assessment of magnitude based on generalities or relatives (qualitative comparisons between alternatives) is inadequate.

9. Provide for overall assessment of total impact - A means for aggregating multiple individual impacts is necessary to provide an evaluation of overall total environmental impact.

10. Pinpoint critical impacts - The methodology must provide a warning system to pinpoint and emphasize particularly hazardous impacts. In some cases the shear intensity or magnitude of impact may justify special attention in the planning process, regardless of how narrowly the impact may be felt.

(b) they had potential for application to water resources projects. The intermediate screen consisted of 19 characteristics (see Table IV.10) which were identified as being desirable. The criteria used in the final screening are listed in Table IV.10. None of the methodologies satisfied all seven final criteria, but each contained salient features. The most important of these features were the concept of impact weighting and scaling, appropriate impact summarization and presentation, and extensive lists of variables. Of the eight methodologies which passed the intermediate screen, 3 were descriptive checklists, 2 were scaling checklists, and 3 were weighting-scaling checklists.

The Waterways Experiment Station reviewed 58 methodologies in 1981, and commented on the advantages and disadvantages of each. This report differed from those discussed previously, in that the authors did not attempt to single out one or several "best" methodologies. Instead, they made a series of comments about the development of methodologies in general. These are summarized as follows:

- EIA methodologies initially sought to be comprehensive, and took the form of matrices, checklists, etc. The total environment was considered, and a number of likely impacts identified. These were then analyzed individually. These methods often ignored secondary impacts and systemic characteristics.

- In order to identify secondary and higher-order impacts, a second generation of methodologies was developed. This included stepped or linked matrices and network analysis.

- The most recent development has been the use of models to represent the dynamics and interrelationships in ecosystems. Comprehensiveness is achieved by use of a number of models or submodels which together represent the environment.

Table IV.10: Factors and Criteria for Solomon, et al. Study (Solomon, et al., 1977)

Nineteen evaluation factors stated in the form of questions:

1. Does it identify environmental items?
2. Does it identify potential impacts?
3. Does it tell how to measure impacts?
4. Is it able to predict potential impacts (short-term and long-term)?
5. Can it interpret the impacts?
6. Is it responsive to Corps environmental guidelines?
7. Is it practical for use in routine field cases (i.e., cost, ease of manipulation, data requirements)?
8. Is there flexibility built in the system so that it can be used for different types of projects (i. e., construction, operation and maintenance, flood control, etc.)?
9. Is the system reliable?
10. Does it highlight major or key issues?
11. Does it tell how to determine predicted change or impact (i.e., scale or magnitude)?
12. How applicable is the methodology to projects of widely different scale?
13. Is there potential for public involvement?
14. What is the degree of objectivity versus subjectivity?
15. Does it display trade-offs?
16. What are the attractive features for Corps projects?
17. What special skills are required of users of the method?
18. What are the limitations of the methodology?
19. Are examples available that document its successful use?

The seven final screening criteria:

a. Responsive to Principles and Standards. The methodology should be responsive to the planning concepts and system of accounts as delineated in Principles and Standards.

b. Comprehensive. The methodology should address the various impacts of water resources projects and programs on the physical-chemical, biological, cultural, and socioeconomic environments. The methodology should encompass all potential beneficial and detrimental impacts. It should also highlight key issues or allow special emphasis on factors of national, state, or local importance (e.g., threatened or endangered species, historic landmarks, and archaeological sites) or factors of intense public concern or controversy.

c. Dynamic. The methodology should be dynamic in terms of the variables considered and the technology used for impact identification, prediction, and assessment. It should be capable of including additional variables and incorporating additional measurement and predictive techniques as technology becomes available.

d. Flexible. The methodology should be responsive to the varying nature, size, and scope of Corps Civil Works projects and programs. Additionally, it must be functional in various regions throughout the United States. Since the effectiveness of impact assessment is directly related to the composite professional judgment of the interdisciplinary team performing the study, it is necessary to use a methodology that is directed toward incorporation of this composite approach and judgment.

e. Objective. The methodology should stress objective analyses of impacts. Baseline conditions should be quantified for variables considered, and changes in each variable that would result from implementation of each alternative plan and the no-action alternative should be predicted. However, lack of measurement techniques and/or predictive technologies for many variables currently precludes total achievement of this goal. In fact, measurement and prediction practices generally dictate a combination of objective analyses and subjective evaluations.

f. Implementable. The methodology must be implementable at the field level and straightforward in approach. It must not be overly complex, or lack descriptions of its application or interpretation of results. Impact assessment must be able to be accomplished within manpower, funding, and time constraints of Corps Districts.

g. Replicable. The results achieved should be replicable. The methodology must provide a sufficient framework so that different interdisciplinary teams using the methodology for the same study will arrive at the same conclusions with regard to the evaluation of the alternatives examined.

INDERENA (1981) listed 10 attributes of methodologies to be used in conducting EIAs. These criteria should be met by the study as a whole, but not necessarily by each individual methodology.

- The study should be complete, addressing all aspects of the environment as well as direct and higher-order effects.
- Methods should be flexible. They should be adaptable to projects of different types and sizes.
- Study should address the net effect of the project, that is, the difference between what will be with the project and what would have been without it.
- Study must be conducted objectively. It should be immune to political pressure.
- Study should include input from all necessary experts.
- Study should use state-of-the-art techniques and methods.
- Criteria used to compare alternatives should be clearly defined in advance.
- Impacts should be quantitatively predicted.
- The total impact must be described, including both beneficial and adverse effects.
- Adverse impacts which cannot be mitigated should be "red-flagged".

Summary for Present Study

The many criteria defined in the previous studies just quoted were summarized for this report. That summary is contained in Table IV.11. For each criterion, one to several indicator comments are listed. As far as possible, the list of criteria has been arranged to correspond with the steps of the assessment process. It should be noted that all criteria would not be applicable in every country. For example, the criteria dealing with regulations obviously do not apply

Table IV.11: Summary of Criteria

CRITERION	COMMENT
1) <u>PRELIMINARY ACTIVITIES</u>:	
Legal Requirements	The review of applicable laws, regulations and ordinances should be thorough.
2) <u>BASELINE STUDIES</u>:	
Comprehensiveness	The study should address all aspects of the environment.
Specificity	The study should identify the specific parameters which make up the environment.
3) <u>IMPACT IDENTIFICATION, QUANTIFICATION AND EVALUATION</u>:	
a) <u>IDENTIFICATION</u>	
Comprehensiveness	The method used should identify impacts in all aspects of the environment.
Data	The method should use data which is available or easy to measure, and should not require costly or highly specialized data inputs.
Expertise	The method should be appropriate for use by technologists working in the field. Importation of specialists should not be necessary.
Higher-order Impacts	Second-, third-, and higher-order impacts should be identified where they occur.
b) <u>PREDICTION</u>	
State-of-the-Art	The prediction techniques should be state-of-the-art for the country and area involved.
Objectivity	Wherever possible, the predictions should be based on models rather than expert judgement.

Table IV.11: Continued

CRITERION	COMMENT
Replicability	The results of the prediction activity should be reproducible.
c) EVALUATION	
Standards	The results of the quantification of impacts should be in such a form as to facilitate the determination of compliance with environmental standards.
Extent	The extent of impacts, along with their magnitude, should be addressed.
Uncertainty and Risk	Where necessary, the likelihood of potential impacts should be indicated, in addition to their magnitude and importance.
4) MITIGATION:	
Red Flags	Adverse impacts which cannot be mitigated should be high-lighted.
5) ASSESSMENT AND COMPARISON OF ALTERNATIVES:	
Comparisons	The method used should permit direct, objective comparison of alternatives, preferably on a numerical basis.
Adaptability (Public involvement)	The method used should be modified to reflect local social and cultural values.
Flexibility	The comparison method should be applicable to projects of different magnitudes.
Implementation	The method employed should be usable by members of the assessment team. It should not be overly complex, costly or time-consuming.
Objectivity	The method should be a structured one, immune to political or other interference.

Table IV.11: Continued

CRITERION	COMMENT
6) <u>DOCUMENTATION</u>:	
Legal Compliance	Where legal requirements are spelled out, the output document should be in compliance.
Public Participation	The output document should enhance public participation. It should be clear, concise, and well illustrated.
Explicit	All indicators and criteria used in the assessment should be unambiguously stated. Methods and techniques used should be listed.
<u>OVERALL</u>:	
Timing	The overall assessment process should run parallel to the design. It should not be a reactive process coming after designs are completed.

in countries which have none. In fact, it would be necessary to decide which criteria apply on a case-by-case basis. Further, some criteria appear to be contradictory. For example, the "expertise" criterion calls for a method which is appropriate for use by technologists in the field, while the "state-of-the-art" criterion asks for up-to-date methods. However, it should be recalled that an assessment involves the use of a series of methods and techniques. In this case, the impact identification activity may employ a checklist, while a mathematical model may be used for quantification. In the following paragraphs, the importance of each criterion will be discussed.

A thorough review of existing laws and regulations is useful for several reasons. First, several project alternatives can be eliminated on the basis of non-compliance. This reduces the cost of assessment. Second, a knowledge of existing requirements is necessary in evaluating impacts and planning mitigation measures. Finally, in rare cases, amendments to laws and regulations are necessary to permit a "must-build" project. The review will identify this necessity.

Comprehensiveness is necessary in the baseline study and in impact identification. A partial assessment can result in unexpected impacts after project implementation, or in a biased choice of alternatives. Neither of these is desirable, and either can necessitate costly remedial measures.

The baseline study should specifically address the components of the overall environment. This will facilitate the identification of particularly sensitive areas, such as threatened or endangered species or sites of cultural importance. When this is done, site selection and mitigation planning can be used to protect these sensitive areas.

The use of general or secondary data for impact identification will reduce the time and cost of this step. Several of the checklist and matrix techniques can be applied without the need for specialized data inputs. The use of simpler methods will permit both the use of available data and available technologists. The results are savings of cost and time.

In impact identification, second-, third-, and higher-order impacts should not be ignored. Many of the adverse health effects of water and waste treatment projects are not first-order, and these must be considered. The use of networks or stepped matrices may be useful here.

The prediction of impact magnitude and importance is the single most important task in an assessment. The methods and models used should be as advanced as is appropriate for the country and area in which the assessment is being done. However, this does not connote the imposition of techniques for which required data and trained personnel are unavailable. The methods should be objective: founded on principles rather than expert judgment. And their results should be reproducible. The evaluation of the importance of specific impacts will be based in part on compliance with desired environmental standards. In addition, the extent of the impact must be considered. Finally, when the effects of a proposed action cannot be definately modelled, the elements of risk and uncertainty should be addressed in evaluating impacts.

Based on the predicted impacts, mitigation measures should be planned. Where an adverse effect cannot be mitigated, it should be "red-flagged" and highlighted in the comparison of alternatives and the final document. This ensures that all concerned are prepared for the impact when it occurs.

The system used to compare alternatives should permit direct, objective comparison on a numerical basis. This will reduce the possibility of biasing of recommendations by special interests. However, the system should be modified prior to use so that it reflects the social and cultural values of the affected population. This will prevent the imposition of foreign values and thus enhance public acceptance of the chosen alternative. It would be desirable to use one system of comparison on several projects in any given area. If this is done, increasing familiarity will improve the expertise of technologists conducting studies and also build the confidence which decision-makers place in the system. However, use of one system can only be realized if it is flexible enough to apply to a variety of sizes and types of projects. Finally, the comparison method should be usable by members of the assessment team, and should not be overly complex, costly or time-consuming.

Where there are legislated guidelines for the study report format, these should be followed. Though this may seem a trivial statement, it is not always followed. A uniform format expedites the review process and can thus save time (and money). The printed document should be simple enough to enhance public participation. Where necessary, two documents should be considered. The first would be a technical document for review by the competent authorities. The second would be a well-illustrated abbreviation for public comment. Whether one or two reports are produced, the criteria, indicators, methods and techniques used in the assessment should be listed. This would ease the review process.

Overall, the assessment should run parallel with the project design. To date, many assessments have been reactive in nature, seeking to justify a particular choice of alternative after it has been designed. The ideal is to integrate environmental assessment into the design process. When this is achieved, delays will be reduced and design quality increased.

CHAPTER V

RESEARCH METHODS

The objectives of this study were:

- to determine the status of EIA in developing countries,
- to review assessment methods developed for use in industrialized nations, and
- to identify methods or salient features of methodologies which are applicable to EIA in the Third World.

To attain these it was necessary to cull information from a large number of sources. Some of the activities in this study are correspondence, database searches, international mail questionnaire, statistical testing, and application of a selection procedure to compare methods. The methods used in each of these activities are described in this chapter.

Correspondence

Letters were sent to several international agencies and to individuals who have published work in EIA. These were mainly of an introductory nature, and solicited information in very general terms. The agencies and persons contacted are listed in Table V.1. As replies were received, new sources of data were identified and more correspondence generated. As a case in point, the letter to ESCAP was

Table V.1: Persons and Organizations Contacted.

Asian Institute of Technology (Thailand)	B.D. Lohani
Aspen Institute for Humanistic Affairs (New Jersey)	H. Cleveland
Caribbean Conservation Association (Barbados)	J. Sheppard
Center for Developing - Area Studies (Canada)	-
Center for Integrative Studies (New York)	M.C. McHale
Center for the Biology of Natural Systems (CBNS) (New York)	S.C. Peyser
East-West Center (Hawaii)	R.A. Carpenter
Economic and Social Commission for Asia and the Pacific (ESCAP) (Thailand)	K.F. Jalal
Environmental Resourced Ltd (United Kingdom)	F. Fisher
European Community Environment Directorate (Belgium)	A. Fairclough
International Institute for Environment and Development (United Kingdom)	B. Johnson
National Environmental Engineering Research Institute (NEERI) (India)	V. Raman
Ontario Ministry of the Environment (Canada)	V.W. Rudik
Organization for Economic Co-operation and Development (OECD) (France)	J. McNeill
Organization of American States (OAS)	-
Pan American Health Organization (PAHO)	F. Butrico
Sociedad Colombiana de Ecologia (Colombia)	E.P. Rodriquez
South Pacific Commission (New Caledonia)	A.L. Dahl
United Nations (UN)	-
United Nations Environment Program (UNEP) (New York, France and Kenya)	D. Lane J.C. Faby M. Nay R.J. Engleman
United States Agency for International Development (USAID)	A.C. Printz T. Johnson
University of Nottingham (United Kingdom)	P. Hills
World Bank	R.J.V. Goodland
World Environment Center (New York)	W. Bassow

prompted by comments contained in the reply from UNEP. In this way, a wide range of potential data sources was contacted.

The replies that were received fall into two categories. The first was those which included reference lists. The relevant material on these lists were sought at OU's library. If not there, copies were ordered from the publishers. The second category was those replies which contained actual reports and documents. These were extremely useful, since they sometimes included material that was not generally available.

Database Searches

Computerized database searches were conducted using the Lockheed Dialog Information Storage and Retrieval System. The first search employed strategy 1 in Figure V.1. Seven bases were reviewed: Conference Papers Index, Comprehensive Dissertation Abstracts, Scisearch, National Technical Information Service, Compendex, Enviroline and Environmental Bibliography. Three bases yielded no references, and the other four provided about 50. Unfortunately, the majority of these were case histories related to environmental health and population control. It was therefore decided to broaden the scope of the search.

The second strategy in Figure V.1 was used to search the same seven bases. Instead of environmental assessment/analysis in developing countries, this search keyed development or environment in developing countries. As a result, a larger set of references was

SEARCH STRATEGY 1

SET	KEYWORDS
1	ASSESSMENT
2	ANALYZING
3	ENVIRONMENTAL
4	(1 OR 2) and 3 ie. $(1 \cup 2) \cap 3$
5	DEVELOPING
6	UNDERDEVELOPED
7	THIRD
8	AREA(S)
9	WORLD
10	COUNTRIES
11	(5 OR 6 OR 7) AND (8 OR 9 OR 10) ie. $(5 \cup 6 \cup 7) \cap (8 \cup 9 \cup 10)$
12	4 AND 11 ie. $4 \cap 11$

Instruction: search for set 12.

SEARCH STRATEGY 2

SET	KEYWORDS
1	DEVELOPMENT
2	ENVIRONMENT
3	1 OR 2 ie. $(1 \cup 2)$
4	DEVELOPING
5	UNDERDEVELOPED
6	THIRD WORLD
7	4 OR 5 OR 6 ie. $(4 \cup 5 \cup 6)$
8	COUNTRIES
9	AREAS
10	NATIONS
11	8 OR 9 OR 10 ie. $(8 \cup 9 \cup 10)$
12	7 AND 11 ie. $(7 \cap 11)$
13	3 AND 12 ie. $(3 \cap 12)$

Search for set 13.

Figure V.1: Computerized Database Searches identified. The Environmental Bibliography base, for example, provided 132. Many of these were relevant to the topic of this study.

International Questionnaire

While the limited literature search was being conducted, it became apparent that current data on the research subject was not readily available in published sources. In order to generate this data, an international mail questionnaire was prepared. In the following paragraphs, the merits and demerits of questionnaires in general are discussed, and considerations relating to this specific questionnaire are presented.

Principles

In their books on questionnaires, Berdie and Anderson (1974), Moser and Kalston (1972) and O'Barr, Spain and Tessler (1973) all list advantages, disadvantages and keys to success of this method of collecting data. The more important of these are summarized in point form as follows.

Advantages:

1) The cost of a mail questionnaire is relatively low, and a very wide audience can be reached.

2) The questionnaire is filled out at the respondent's convenience. He may do it all at one sitting, or spread it over several. He can pause as required to look up references. And he does it when he has the time to devote to it. In addition, many technologists are familiar with the use of questionnaires.

3) The questions are presented uniformly to each respondent, and the chance of bias due to voice inflection or facial expression is absent.

4) The questions can be set up in such a way that the answers can be easily tabulated and analyzed.

Disadvantages:

1) The analyst has no control over response rate. A low rate of response may be increased by follow-up letters or reminders. However, these increase the length of time to complete the study. For international questionnaires, a response rate of 20% is normal.

2) The responses cannot be checked for reliability or validity. In this context, reliability relates to stability over time. Will the respondent interpret the question in the same way if he reads it on several widely spaced occasions? Validity, on the other hand, is concerned with the focus of the question. Is the respondent answering the precise question which the analyst is asking?

3) Some respondents are prejudiced against questionnaires because of the impersonality of the system. Others object to the system because they feel that their responses will be misused.

4) There is no guarantee as to who actually completes the form: the addressee, his assistant, his secretary, or his spouse!

Keys to Success:

1) The analyst must have a clear concept of what he is trying to find out, and who he is questioning.

2) Every field has its own jargon. If these words or phrases are used, they must be used in context.

3) The questions must be constructed to avoid being offensive to respondents. The reader should not feel that he is being talked down to.

4) Questions should be clear and concise. This will enhance both reliability and validity.

5) The overall form should not be lengthy. A questionnaire which can be completed in fifteen minutes will have a higher response than one which takes two hours. Naturally, too short a questionnaire will yield little information. What is required is a form which seeks as much data as possible while still respecting the respondent's time.

6) An orderly layout enhances response rates. If the questions are divided into sections, a respondent may decide to answer only some sections. If not, he may decide not to answer any questions, because it would be difficult to find those he can answer.

7) Questions which require short answers or check-off answers have a higher response rate than those which seek essay-type answers.

8) Questions should be neutral. They should not suggest a particular answer to the respondent.

Based upon these principles, it was decided to compose a questionnaire of not more than four pages, accompanied by a detailed cover letter. The questionnaire was sent to environmental technologists in developing as well as industrialized countries. In this way, it was possible to develop a picture of EIA in developing countries and also to compare perceptions of environmental problems in developing countries with those in industrialized countries. The remainder of this section deals with the construction and distribution of the questionnaire.

Questionnaire Construction

The international questionnaire contained 40 questions in 5 sections. Space was provided for respondents to fill in their names and addresses. However, the cover letter advised that this was optional. In fact, anonymous responses were received from both industrialized and developing countries. The five sections in the questionnaire were personal data, current status of EIA in country, environmental parameters, EIA methodologies and miscellaneous. The specific questions in each section are as follows.

Personal: Respondents were asked to name their country and indicate the sector in which they are employed, their highest level of formal education, and whether they had specialized training in environmental science (see Table V.2). The employment question was included to test whether persons employed in different sectors perceive EIA differently. The education data was used to check whether a person's educational attainment affects his perception of environmental affairs. Finally, the question on specialized training in environmental science was used to investigate the effects of this type of training on environmental perceptions.

Current Status: Eight questions on the current status of EIA in the respondent's country were included. These are listed in Table V.3. Questions 5 and 6 were factual, and referred to the state of environmental legislation and technology in the country. The responses to these questions were used to develop a summary table of current status of environmental legislation and technology in developing and industrialized countries. The remaining questions were subjective in nature. They related to the respondent's perception of environmental affairs and the relationship between environment and development in his country. The answers to these questions were used to compare these perceived relationships among developing countries and between developing and industrialized countries.

Environmental Parameters: The overall environment consists of physical-chemical, biological, cultural and socio-economic components. Depending upon the economic and social conditions in a country, certain components may be considered more important than others. Eighteen

Table V.2: International Questionnaire: Personal Data

---

1. Please name your country:

   ____

2. In what sector are you employed?

   ( ) Government Service

   ( ) Education

   ( ) Industry

3. What is your highest level of formal education?

   ( ) Pre-University

   ( ) Bachelor's Degree

   ( ) Graduate Study

4. Do you have specialized training in Environmental science?

   ( ) Yes

   ( ) No

Table V.3: International Questionnaire: Current Status

Question		Response		
(5)	Are there laws in your country which require Environmental Impact Assessment (EIA) on major projects?	Yes	No	Don't Know
(6)	Have the environmental effects of any major project been assessed prior to its implementation in your country?	Yes	No	Don't Know
(7)	Are present efforts to protect your country's environment adequate?	Yes	No	Don't Know
(8)	Is EIA necessary in your country at this time?	Yes	No	Don't Know
(9)	Are there enough trained people in your country to conduct EIA on major projects at this time?	Yes	No	Don't Know
(10)	How will EIA significantly affect project costs?	Increase/No Effect/Decrease/Don't Know		
(11)	How will EIA affect development in your country?	Enhance/No Effect/Retard/Don't Know		
(12)	How will EIA affect overall project planning?	Enhance/No Effect/Retard/Don't Know		

parameters were listed in Part 3 of the questionnaire. Seven of these (questions 13 to 19) came from the physical-chemical environment, five from the biological (questions 20 to 24), three from the socio-economic (questions 25 to 27), and three from the cultural (questions 28 to 30) (see Table V.4). Respondents were asked to rate the importance of each parameter in assessing a project in their country. A scale of zero to five was to be used, where 0 indicated that changes in the parameter could be ignored, one that it is marginally important, and so on up to five for a parameter which was extremely important. The responses in this section were used for three sets of comparisons:

- comparing the importance placed on different components within a country or geographical region;
- comparing the importance placed on each component in different developing countries; and
- comparing the importance placed on each component in developing countries with that in industrialized nations.

EIA Methodologies: In order to determine which EIA methodologies developed in industrialized nations are applicable in developing countries, it was necessary to establish a list of criteria. In Part 4 of the questionnaire, respondents were presented with a list of nine criteria (see Table V.5). They were asked to rate these on a scale of zero to five, as in Part 3. They were also asked to include any other criteria which they considered important in Part 5.

The criteria in this section were chosen from Table IV.11. The use of these criteria to rate the various steps in an environmental study is as follows.

- Comprehensiveness relates to both impact identification and the baseline survey.

Table V.4: International Questionnaire: Environmental Parameters

	Parameter	Score
(13)	Suspended solids in streams	______
(14)	Temperature in streams	______
(15)	Sulfur dioxide in atmosphere	______
(16)	Visibility (presence of smoke and smog)	______
(17)	Changes in topography of land	______
(18)	Dissolved solids in ground water	______
(19)	Salinity in marine and estuarine waters	______
(20)	Replacement of natural vegetation	______
(21)	Obstruction of animal migration routes	______
(22)	Reduction of terrestrial or aquatic species diversity	______
(23)	Reduction in numbers of a given species	______
(24)	Rare or endangered species	______
(25)	Employment	______
(26)	Reduced food imports	______
(27)	Health effects	______
(28)	Archaeological sites	______
(29)	Scenic areas	______
(30)	Effects on religious practices	______

Table V.5: International Questionaire: EIA Methodologies

Criterion: Description	Score
(31) Comprehensiveness: The methodology must address the various parameters which make up the environment, and the interrelationships between these parameters.	______
(32) Objectivity: The methodology must provide impersonal, objective and unbiased measurements, which are unaffected by political or other interference.	______
(33) Flexibility: The methodology must be adaptable to projects of different sizes and types.	______
(34) Implementation: The methodology must be usable by technologists in the field. It should not be overly complex, costly or time-consuming.	______
(35) Data: The methodology should use data which is available or easy to measure. It should not require costly or highly specialized data inputs.	______
(36) Comparisons: The methodology should permit direct comparison between project alternatives, preferably on a numerical basis.	______
(37) Public Involvement: The methodology should incorporate public opinion. The documents produced should enhance public participation.	______
(38) Impact Prediction: The methodology should identify potential impacts and predict their magnitude.	______
(39) Expertise: The methodology should be appropriate for use by technologists working in the field. Importation of specialists should not be necessary.	______

- Objectivity is desirable in impact prediction as well as in the comparison of alternatives.

- Flexibility implementation and comparisons all refer to the comparison of alternatives step.

- Data and expertise criteria both refer to the impact identification step.

- Impact prediction refers to the quantification process.

- Public involvement refers to the comparison of alternatives. These ratings were also used to compare the attitudes to the public involvement in different countries.

This is summarized in Table V.6.

Miscellaneous: This section was included to allow respondents to address any issues of concern not included in the previous sections. The actual question asked was:

> "Q40: Are there any other comments that you wish to make? For example, what problems would make the use of EIA difficult in your country? Please include additional sheets as needed."

The responses to this question were far more open-ended than those to the more structured parts of the questionnaire. Those who chose to make additional comments addressed a wide variety of issues, many of which were extremely instructive to this study.

Cover Letters: Tables V.7 and V.8 are the cover letters which accompanied the questionnaires to developing and industrialized nations, respectively. The latter is essentially the same as the former, except that it was extended to explain the role of responses from industrialized countries in a study of EIA in developing countries.

Table V.6: Use of Criteria to Rate EIA Steps

	Step in Environmental Study			
CRITERION	Impact Identification	Baseline Survey	Impact Quantification	Comparison of Alternatives
Comprehensiveness	X	X		
Objectivity			X	X
Flexibility				X
Implementation				X
Comparisons				X
Data	X			
Expertise	X			
Impact Prediction			X	
Public Involvement				X

Table V.7: Cover Letter to Developing Countries

The University of Oklahoma at Norman

School of Civil Engineering and Environmental Science

January 25, 1982

Dear :

I am a native of Trinidad and Tobago (West Indies) currently enrolled in a doctoral program at the University of Oklahoma. My research topic is "Environmental Impact Assessment in Developing Countries". Having learned of your interest in environmental matters, I am writing to seek your assistance in my work. Specifically, this letter is meant to explain the attached questionnaire, which I hope you can find the time to complete and return.

The purpose of the questionnaire is to determine the status of environmental impact assessment in developing countries, and to investigate the environmental concerns of persons like yourself. The form is divided into five parts. Part one is a personal profile and part two addresses the current status of environmental assessment in your country. Part three is a list of environmental parameters, which you are asked to rate, and part four is a list of criteria for assessing methodologies, which you are also asked to rate. Part five is a miscellaneous section where you may include any concerns which were not specifically addressed earlier. Although space is provided for your name and address, please view this as optional. If for some reason you wish to remain anonymous, we shall respect this. But whether or not you choose to give your name, we are interested in hearing your views.

Part one is included to gain a little information about yourself. This data will be used to compare responses by people from different countries and with different backgrounds. In part two, questions 5 and 6 refer to the state of environmental legislation and technology in your country. The remaining questions are subjective in nature. They all relate to your perception of environmental affairs in your country.

The overall environment is composed of physical-chemical, biological and socio-economic aspects. There are a host of parameters in each aspect. Eighteen parameters are listed in part 3, and you are asked to rate the importance of each. Your responses will be analyzed to determine the relative importance of each aspect of the environment in your country at the present time.

Many methodologies for environmental assessment have been developed to date, mainly in the developed countries. Part of my research is to study these methodologies and determine which will be useful in developing countries. Eight criteria are listed in part 4, and you are asked to rate these. The aggregate response to the questionnaire will determine what characteristics of methodologies are important in developing countries. The criteria which are considered most important can then be used to screen methodologies for use in developing countries.

I hope that you can find the time to complete and return the questionnaire. My work depends quite heavily on your cooperation. Thank you for your assistance, and I look forward to your reply.

Yours sincerely,

George K. Sammy
Doctoral Candidate
University of Oklahoma

GKS/ler

Attachments

Table V.8: Cover Letter to Industrialized Countries

March 25, 1982

Dear :

I am a native of Trinidad and Tobago (West Indies) currently enrolled in a doctoral program at the University of Oklahoma. My research topic is "Environmental Impact Assessment in Developing Countries". Having learned of your interest in environmental matters, I am writing to seek your assistance in my work. Specifically, this letter is meant to explain the attached questionnaire, which I hope you can find the time to complete and return.

One major aspect of my work is a questionnaire, similar to that attached, which has been sent to several hundred technologists working in the Third World. In order to compare the perception of environmental problems in the developing countries with the perception of these problems in industrialized nations, the attached questionnaire is being sent to you and other environmental scientists in developed countries. The form is divided into five parts. Part one is a personal profile and part two addresses the current status of environmental assessment in your country. Part three is a list of environmental parameters, which you are asked to rate, and part four is a list of criteria for assessing methodologies, which you are also asked to rate. Part five is a miscellaneous section where you may include any concerns which were not specifically addressed earlier. Although space is provided for your name and address, please view this as optional. If for some reason you wish to remain anonymous, we shall respect this. But whether or not you choose to give your name, we are interested in hearing your views.

Part one is included to gain a little information about yourself. This data will be used to compare responses by people from different countries and with different backgrounds. In part two, questions 5 and 6 refer to the state of environmental legislation and technology in your country. The remaining questions are subjective in nature. They all relate to your perception of environmental affairs in your country. A comparison of the responses to questions 7 to 12 from developed nations with those from the third world will indicate similarities or differences in the perceived relationship between the environment and development.

The overall environment is composed of physical-chemical, biological and socio-economic aspects. There are a host of parameters in each aspect. Eighteen parameters are listed in part 3, and you are asked to rate the importance of each. Your responses will be compared with those from developing countries to determine whether the same aspects are considered important in industrialized and developing countries.

Many methodologies for environmental assessment have been developed to date, mainly in the developed countries. Part of my research is to study these methodologies and determine which will be useful in developing countries. Eight criteria are listed in part 4, and you are asked to rate these. The aggregate response from the third world will determine what characteristics of methodologies are important in developing countries. The criteria which are considered most important can then be used to screen methodologies for use in developing countries. Your response will be compared with theirs to determine whether a different emphasis is necessary in methodologies to be used in the third world.

I hope that you can find the time to complete and return the questionnaire. My work depends quite heavily on your cooperation. Thank you for your assistance, and I look forward to your reply.

Yours sincerely,

George K. Sammy
Doctoral Candidate
University of Oklahoma

GKS/ler

Attachments

Language

In order to enhance the response rate, the questionnaire and cover letter to developing countries was translated into French and Spanish. England, France and Spain were the major colonizers during the imperial era. Thus, it was felt that the majority of third world technologists would be conversant in either English, French or Spanish. Appendix A lists the languages spoken in each of the developing countries to which the questionnaire was sent. It also lists the language in which the questionnaire was sent to each country. Where none of the questionnaire languages was spoken in a particular country, the questionnaire was sent in English. Table V.9 is a summary of the number of questionnaires in each language that was sent to each geographical region. It is readily apparent that the language distributions were considerably different in each developing region. The vast majority of the Spanish translation went to the Americas, and the majority of the French translation went to Africa and the Middle East.

One of the limitations of using several languages for the questionnaire is that it builds bias into the responses. Each language has its own nuances, and exact translation is therefore impossible. However diligent the translator may be, the translation cannot convey the precise shades of meaning as the original. In spite of this limitation, it was felt that the anticipated increased response rate justified the use of several languages. To reduce the bias, special care was taken in translating technical jargon.

Table V.9: Summary of Questionnaire Languages to Developing Nations

Region	No. of Questionnaires Sent in Each Language		
	English	French	Spanish
Africa and Middle East	193	62	1
Americas	87	6	178
Asia and the Pacific	187	5	0
Europe	27	0	0
TOTAL	514	73	179

NOTE: See Appendix A for language breakdown by country.

Mailing List

One of the most difficult aspects of this research project was the assembly of a list of persons to whom the questionnaire would be sent. Because of the technical nature of the questions asked, it was decided to send it to technologists active in environmental disciplines in developing and industrialized countries. Because of this, the results will not be representative of public perceptions of EIA. Instead, the results will represent the views of technologists on the subject.

The following are the sources that were used to develop the mailing list.

1. The University of Oklahoma: Dr. Larry Canter has put together a list of persons interested in environmental affairs. This was particularly useful as a source for the United States and Canada.

2. The University of Aberdeen, Scotland: Dr. Brian Clark very graciously made his mailing list available. This contained many names of individuals in Europe and the third world.

3. Research Organizations: Mordy and Sholtys (1970) have published a directory of organizations concerned with environmental research. The international section of this directory listed several research institutions in developing countries.

4. Engineering Schools: Geographics (1977) has published a World directory of engineering schools. Questionnaires were sent to heads of these schools in developing countries, with a request that they be forwarded to the appropriate staff member for response.

5. Engineering Societies: The Engineers Joint Council (1979) has published a directory of engineering societies and related organizations. Questionnaires were sent to the secretaries of third world societies, with a request that they be forwarded to the appropriate member for response.

6. Sierra Club Directory: This document lists environmental organizations throughout the world (Tryzna and Coan, 1976). Questionnaires were sent to those in developing countries.

7. UNEP Directory: This book lists individuals and institutions active in environmentally-sound and appropriate technologies (United Nations Environment Program, 1979). It was a useful source of addresses in the third world.

8. United Nations: A copy of the questionnaire was sent to the leader of the UN mission of each developing country. Some were completed by the staff at the mission, others were forwarded to the country in question, and some were sent back with names and addresses to contact.

9. Miscellaneous: Some names and addresses were obtained from the attendance lists of various conferences. Many people to whom the questionnaire was sent suggested other addressees. At the request of the organizers, several questionnaires were sent for distribution at the First Congress of the Colombian Ecological Society.

Statistical Tests

In this research, statistical tests were used to distinguish statistically significant differences from those which could be attributed to random variations. Three tests were used: the chi-square goodness-of-fit test, the chi-square test for independence, and the Kruskal-Wallis test. Each of these will be described in this section. The actual analyses are found in Appendix B, and discussions of the results are found in the appropriate sections of Chapters VI to IX.

The Chi-square Goodness-of-Fit Test

A goodness-of-fit test is one which seeks to decide if a specific sample of data could reasonably be assumed to have a particular underlying distribution. In a case where the underlying distribution is known, the goodness-of-fit test is one of

H_0: $f_Y(y) = f_0(y)$

versus

H_1: $f_Y(y) \neq f_0(y)$

where $f_Y(y)$ = distribution of sample, and

$f_0(y)$ = underlying distribution.

In the chi-square test, this is done by dividing the range of results into a series of k non-overlapping intervals. The test then becomes

H_0: $P_1 = P_1', P_2 = P_2', \ldots P_k = P_k'$

versus

H_1: $P_i \neq P_i'$ for at least one i

where

P_i = probability that a result will fall in interval i in the sample, and

P_i' = probability that a result will fall in interval i in the underlying distribution.

The test procedure is as follows. First, a convenient number of suitable intervals is selected. In the example in Table V.10, a total of four intervals were chosen. The number of observations in each range in the sample is listed in the "observed frequency" column. Based on the underlying distribution, the number of observations which would be expected in each interval for that size of sample is computed. These are listed in the "expected frequency" column. The test statistic, c, is then computed from

$$c = \sum_{\text{all } i} \frac{(O_i - E_i)^2}{E_i}$$

where

O_i is the observed number of results in interval i, and

E_i is the expected number of results in interval i.

Table V.10: Chi-Square Goodness-of-fit Test

Example: Test whether the following series of numbers is uniformly distributed.

74	77	80	82	82
85	80	75	75	72
90	87	73	83	86
83	83	80	87	81

	Frequency	
Interval	Expected	Observed
71-75	5	5
76-80	5	3
81-85	5	8
86-90	5	4
TOTAL	20	20

$$c = \frac{(5-5)^2}{5} + \frac{(3-5)^2}{5} + \frac{(8-5)^2}{5} + \frac{(4-5)^2}{5}$$

$$= 0 + .8 + 1.8 + .2 = 2.8$$

from chi-square tables, for k-1 = 3 degrees of freedom,

$\alpha > .25$

Hence, accept Ho.

If k is the number of intervals chosen, then c has a chi-square distribution with k-1 degrees of freedom. From standard tables, it is possible to determine the probability of a type I error: the α value. In this case, α represents the probability of assuming that the sample does not have the underlying distribution when in fact it does. In the example in Table V.10, α is greater than .25, so H_0 would be accepted. That is, it can reasonably be assumed that the series of numbers is uniformly distributed (Larsen and Marx, 1981; and Conover, 1980).

Chi-square Test for Independence

In general, tests for independence ask the question: can any insight into the probable value of variable B be gained by knowing the value of variable A? In this specific case, the question is: does knowledge of a respondents country of origin, employment or education give any indication of his probable attitude to an environmental issue? If it does not, then the attitude is said to be independent of origin, employment or education. Here, the test is

H_0: Variable 1 and Variable 2 are independent,

versus

H_1: Variable 1 and Variable 2 are dependent.

The test procedure is similar to the previous one, and is summarized in Table V.11. The results are tabulated in a contingency table, as shown. Each X_{ij} represents the number of times response i was received from area j. The marginal totals n_i and c_j are the sum of Xs along the rows and columns, respectively. Using the n and c values, as well as N (the total number of observations), an expected value

Table V.11: Chi-Squared Test for Independence

Contingency Table: X_{ij} = number of times response i was received from area j.

	AREA 1	AREA 2	AREA 3	AREA j	
RESPONSE 1	X_{11}	X_{12}	X_{13}	X_{1j}	$= n_1$
RESPONSE 2	X_{21}	X_{22}	X_{23}	X_{2j}	$= n_2$
RESPONSE 3	X_{31}	X_{32}	X_{33}	X_{3j}	$= n_3$
RESPONSE i	X_{i1}	X_{i2}	X_{i3}	X_{ij}	$= n_i$
	C_1	C_2	C_3	C_j	N

Computation:

For each i, j there is a value $E_{ij} = (n_i C_j)/N$

Test H_o: area and response are independent

vs H_2: area and response are dependent

by rejecting H_o if

$$\sum_{ij} \frac{(X_{ij} - E_{ij})^2}{E_{ij}} \geq X^2 \alpha, (i-1)\ (j-1)$$

Note: a. The rule of thumb for sample size is that the numerical value of any E_{ij} should not be less than 5. If this occurs, the areas can be regrouped until the rule is satisfied.

b. Responses 1 to i are alternative responses to one question. Thus, i may be as small as 2, or larger.

(ref. Larsen and Marx, 1981)

(E_{ij}) is computed for each cell. The test statistic is computed as shown in Table V.11, and it has a chi-square distribution with (i-1)(j-1) degrees of freedom (Larsen and Marx, 1981).

Kruskal-Wallis Test

This test is a non-parametric test for comparing random samples drawn from several different populations. The test is

H_0: all populations are identical,

versus

H_1: some populations tend to give greater results.

The test is a completely randomized design, and is based on a ranking procedure. Thus, the test is limited to data that can be arranged in order of magnitude. Because of the large numbers of tied responses that occur in this data set, two versions of the test are described here. The first is the general form, and the second is adapted for use with categorical data (Conover, 1981).

An example of the general form of the Kruskal-Wallis Test is shown in Table V.12. In the data set, V_{ij} is the value of observation j in group i. The first step is to rank all observations in ascending order from smallest to largest. R (V_{ij}) represents the rank of observation V_{ij}. When there are tied values in the data, mid-rank values are assigned. For each group, the sum-of-the-ranks (R_i) is computed. If there are no tied values, the test statistic can be calculated directly from the sums-of-the-ranks (R_i), the number of observations in each group (n_i), and the total number of observations (N). The formula for T is given in Table V.12. If there are tied

Table V.12: The General Kruskal-Wallis Test

Data:

Group 1	Group 2	Group 3	Group 4
V_{11}	V_{21}	V_{31}	V_{41}
V_{12}	V_{22}	V_{32}	V_{42}
V_{13}	V_{23}		V_{43}
V_{14}			

Computations:

	Group 1		Group 2		Group 3		Group 4	
	Obs.	Rank	Obs.	Rank	Obs.	Rank	Obs.	Rank
	V_{11}	12	V_{21}	6	V_{31}	2	V_{41}	7
	V_{12}	4	V_{22}	1	V_{32}	5	V_{42}	8
	V_{13}	11	V_{23}	10			V_{43}	3
	V_{14}	9						
R_i:		36		17		7		18
n_i:		4		3		2		3

$N = 12$

With Ties: $S^2 = \frac{1}{N-1}\left[\sum_{\text{all } ij} R(V_{ij})^2 - N\frac{(N+1)^2}{4}\right]$

No Ties: $S^2 = \frac{N}{12}(N+1)$

Generally: $T = \frac{1}{S^2}\left[\sum_{i=1}^{k} \frac{R_i^2}{n_i} - N\frac{(N+1)^2}{4}\right]$

No Ties: $T = \frac{12}{N(N+1)} \sum_{i=1}^{k} \frac{R_i^2}{n_i} - 3(N+1)$

Test H_o: All groups give equivalent responses

Versus H_1: Some groups give higher responses than others
by rejecting H_o if $T \geq \chi^2_{\alpha, k-1}$.

(ref. Conover, 1981).

values, it is first necessary to compute S^2 from N and all values of R (V_{ij}). T can then be calculated from S^2, R_i, n_i and N, as shown. The test statistic has a chi-square distribution with k-1 degrees of freedom, where k = the number of groups being compared.

When there are many ties among the data, application of the general form of the test becomes tedious. Since respondents to the questionnaire were asked to rate parameters and criteria on a scale of zero to five, many ties did occur. A special form of the Kruskal-Wallis test to handle data of this type is available.

The first step in this procedure is to arrange the data into a matrix as shown in Table V.13. This array is similar to the one used in the previous test, but there is an important difference. In the chi-square test, the responses may be arranged in any order. In this test, they must be placed in strict ascending order. The test statistic, T, is calculated as shown in Table V.13. T has a chi-square distribution with c-1 degrees of freedom, where c = the number of populations being compared.

Table V.13: The Kruskal-Wallis Test for Categorical Data

Data: O_{ij} = number of times response i was received from area j.

Response \ Area:	1	2	. . .	c	Row Total	Average rank($\bar{R}i$)
1	O_{11}	O_{12}		O_{1c}	t_1	$(t_1+1)/2$
2	O_{21}	O_{22}		O_{2c}	t_2	$t_1+(t_2+1)/2$
. . .						
r	O_{r1}	O_{r2}		O_{rc}	t_r	$t_1+t_2...t(t_c+1)/2$
	n_1	n_2		n_c	N	= grand total

Calculations:

(1) Calculate sum of the ranks for each column (R_j):

$$R_j = \sum_{i=1}^{r} O_{ij} \bar{R}_i$$

(2) Calculate S^2:

$$S^2 = \frac{1}{(N-1)} \sum_{i=1}^{r} t_i \bar{R}_i{}^2 - N(N+1)^2/4$$

(3) Calculate test statistic (T):

$$T = \frac{1}{S^2} \left[\sum_{j=1}^{c} \frac{Rj^2}{n_j} - \frac{N(N+1)^2}{4} \right]$$

Test H_o: All areas give equivalent responses.

versus

H_1: Some areas give higher responses than others by rejecting H_o if $T \geq \chi^2$ α, c-1.

(ref. Conover, 1981)

CHAPTER VI

RESULTS OF QUESTIONNAIRE

In this chapter, the results of the international questionnaire are discussed. The first section deals with the response received from various countries. Section two deals with EIA legislation and practice, section three deals with the perceived need for EIA, and section four deals with the anticipated cost of EIA and its effect upon development. These three sections are all based upon responses to Part 2 of the questionnaire. Section five of this chapter addresses the importance attached to different environmental parameters in different countries, based on responses to Part 3 of the questionnaire. The sixth section is a discussion of some of the criteria for evaluating methodologies which were presented in Part 4 of the questionnaire. The mean importance scores of these criteria will be used in Chapters VII, VIII and IX. The final section of this chapter summarizes general comments received in Part 5 of the questionnaire, as well as from persons who chose not to complete the questionnaire.

Response

Response Rate

The questionnaire was sent to 139 developing and 25 industrialized countries. Of the developing countries, 63 were in Africa and the Middle East, 41 in the Americas, 30 in Asia and the Pacific, and 5 in Europe. Table VI.1 lists the countries which responded, and Table VI.2 lists those which did not. In each table, the number of questionnaires sent to each country is noted. The responses received can be divided into two categories: completed questionnaires and informative letters. The number of responses in each category from each country is listed in Table VI.1. Also listed is the number of letters that were returned undelivered from each country.

Based on the number of countries, the response rate was as follows. Fifty percent of the countries in Africa and the Middle East responded, and 44% returned completed questionnaires. Of the developing countries in the Americas, 59% responded and 56% completed the questionnaire. For Asia and the Pacific, these percentages were 63% and 60%, respectively, and for the developing nations of Europe 80% and 60%. Finally, 91% of the industrialized nations replied, and 87% returned the questionnaire.

Based on the actual number of questionnaires sent, the response rates are lower. These rates are expressed as a percentage of the number sent minus the number returned undelivered. It will be noted that the sum of the replies received does not equal the number of questionnaires sent. There are three reasons for this. First, some recipients did not reply. Second, some recipients copied the questionnaire and distributed it to their colleagues. The author is grateful to those who did. Third, it is reasonable to assume that not

Table VI.1: Response to International Questionnaire.

Country	Number* Sent	Replies Received		
		Completed Questionnaire	Letter	Returned Undelivered
AFRICAN AND THE MIDDLE EAST				
Bahrain	4	1	-	-
Botswana	3	1	-	-
Burundi	2	1	-	-
Cameroon	6	1	2	-
Canary Islands	1	1	-	-
Egypt	12	1	-	1
Ethiopia	7	2	-	1
Ghana	8	2	-	-
Iran	6	4	1	-
Iraq	4	1	-	1
Ivory Coast	5	-	1	-
Jordan	4	1	-	-
Kenya	11	1	2	-
Kuwait	5	1	1	-
Liberia	4	1	-	-
Madagascar	3	1	-	-
Malawi	5	1	1	-
Mauritius	3	1	-	-
Mozambique	4	2	-	-
Nigeria	10	2	-	1
Oman	5	1	-	-
Saudi Arabia	12	1	1	4
Senegal	6	-	1	-
Sierra Leone	2	2	-	-
Somalia	2	1	-	-

*number sent does not equal replies received. See text for reasons.

Country	Number* Sent	Replies Received		
		Completed Questionnaire	Letter	Returned Undelivered
South Africa	17	4	-	3
Tanzania	7	1	1	-
Togo	2	-	1	-
Uganda	6	3	2	-
Zaire	5	1	-	-
Zambia	6	3	1	-
THE AMERICANS				
Argentina	12	3	-	1
Bahamas	6	1	1	1
Barbados	10	1	3	-
Bermuda	3	1	-	-
Brazil	31	7	1	1
Canada**	56	31	3	2
Cayman Islands	1	1	-	-
Chile	11	3	2	1
Colombia	20	3	2	0
Costa Rica	5	3	1	-
Dominica	2	-	1	-
Dominican Republic	7	3	-	-
Ecuador	6	1	-	-
Guyana	6	1	-	-
Mexico	24	5	-	1
Nederlands Antilles	1	1	-	-
Panama	3	1	-	-
Peru	9	2	1	1

**industrialized country

Table VI.1: (continued)

Country	Number* Sent	Replies Received		
		Completed Questionnaire	Letter	Returned Undelivered
Puerto Rico	15	4	1	2
St. Lucia	3	1	-	-
Surinam	3	1	-	-
Trinidad and Tobago	13	7	1	-
U.S.A.**	137	68	10	6
Uruguay	5	1	1	-
Venezuela	21	5	1	2
Virgin Islands (U.S.)	5	1	-	-
ASIA AND THE PACIFIC				
Australia**	3	4	-	-
Bangladesh	13	2	1	-
Bhutan	1	1	-	-
China	12	-	1	-
Fiji	5	2	1	-
French Polynesia	2	1	-	-
Guam	3	1	-	-
India	31	6	-	3
Indonesia	12	7	-	-
Japan**	5	6	-	-
Korea, South	12	3	-	2
Malaysia	10	2	1	-
Nepal	7	2	-	-
New Caledonia	3	2	-	-
Pakistan	5	1	-	-
Papua New Guinea	6	3	1	-
Phillippines	11	3	1	-

Country	Number* Sent	Replies Received		
		Completed Questionnaire	Letter	Returned Undelivered
Sri Lanka	10	4	-	-
Taiwan	4	2	-	-
Thailand	15	9	1	1
U.S. Trust of Pac. Is.	3	1	-	1
EUROPE				
Austria**	1	1	-	-
Belgium**	4	2	-	1
Cyprus	5	1	-	-
Czechoslovakia**	4	1	-	-
Denmark**	3	1	-	-
Finland**	3	3	-	-
France**	6	2	1	-
Germany, West**	12	3	1	1
Greece**	8	2	-	-
Greenland	1	1	-	-
Ireland**	4	2	-	-
Italy**	3	-	1	-
Luxemburg**	1	1	-	-
Malta	5	-	1	-
Netherlands**	7	4	-	-
Norway**	4	1	-	-
Poland**	3	1	-	-
Portugal**	7	2	-	-
Spain**	2	2	-	-
Switzerland**	2	1	-	-
Turkey	13	4	-	-
United Kingdom**	23	11	2	-
Yugoslavia**	4	1	-	-

Table VI.2: Countries Which Did Not Respond

AFRICA & MID. EAST:

Algeria (3*)

Angola (2)

Benin (3)

Central African Republic (2)

Chad (3)

Comoros (1)

Congo (3)

Djbouti (2)

Equatorial Guinea (1)

Gabon (1)

Gambia (4)

Guinea (2)

Guinea - Bissau (2)

Lebanon (3)

Lesotho (2)

Libya (12)

Mali (3)

Mauritania (1)

Morocco (5)

Niger (2)

Qatar (1)

Reunion (1)

Rwanda (3)

Sao Tome & Principe (1)

Seychelles (1)

Sudan (3)

Swaziland (1)

Syria (4)

Tunisia (6)

Upper Volta (2)

United Arab Emirates (1)

Yemen Arab Republic (2)

AMERICAS:

Anguilla (1)

Antigua (1)

Belize (2)

Bolivia (4)

Cuba (6)

El Salvador (3)

Falkland Islands (1)

French Guiana (3)

Grenada (3)

Guatemala (4)

Haiti (3)

Honduras (3)

Jamaica (7)

Monserrat (1)

Nicaragua (3)

Paraguay (1)

St. Vincent (3)

ASIA & PACIFIC:

Afghanistan (1)

American Samoa (1)

Burma (5)

Kampuchea (3)

Korea, North (3)

Laos (1)

Maldives (2)

Mongolia (5)

Solomon Islands (1)

Vanuatu (1)

Vietnam (4)

DEVELOPING EUROPE:

Albania (3)

INDUSTRIALIZED EUROPE:

Hungary (1)

Romania (1)

* Number of questionnaires sent.

all undelivered letters were returned, especially from third world countries. The actual response rates were:

	% responding	% completing questionnaire
Africa & Middle East	27	17
Americas (developing)	28	22
Asia & Pacific	34	30
Europe (developing)	26	22
All developing	28	22
Industrialized	59	52

The response from developing countries was somewhat higher than expected. That from industrialized nations was much higher than expected.

Distribution

In order to determine whether the response received was biased, a goodness-of-fit test was done using the distributions in the McHale's listing of nations and the World Bank categories. The list of developing countries presented in Chapter III includes nations from the McHale's group C, D and E, and from four World Bank groups: centrally planned economy (cp), low income (li), middle income (mi), and capital-surplus oil-exporter (oe). The distribution of individual responses and the distribution of countries from which responses originated were each compared with the distribution of all countries listed. The first set of tests used the McHale's groups, and the second set used the

World Bank groups. In each set of tests, the comparison was done for each of the four regions and then for all developing countries. The test procedure was a chi-square goodness-of-fit, and the computations are summarized in Appendix B. The distributions, expressed as percentages, are listed in Table VI.3.

The results of both sets of tests were in agreement. The distribution of individuals responding was not the same as the overall distribution of developing countries. However, it can reasonably be assumed that the distribution of countries from which responses came is the same as the overall distribution of developing countries. Examination of Table VI.3 indicates the bias among the individual responses. The reason was a predictable one. The number of individuals responding from any given country tended to be larger for the more affluent nations, and smaller for the less affluent ones.

In order to eliminate this bias, it was decided to analyze the data by country rather than by individual. This was done by averaging all the individual responses from a given country for each of the questions which required numerical responses. The result was an "average country response" for each of questions 13 to 39. To be consistent, this averaging was also done on the responses from industrialized nations. Thus, each country's responses became a single sample point instead of several individual ones.

A second bias in both individual and country responses is that no questionnaires were returned from the centrally planned economy countries in the third world. Questionnaires were sent to these nations, but no replies were received. As a result, the views of

Table VI.3: Distribution of Responses from Developing Countries

Distribution	% of Total in Each Category						
	McHales' Groups			World Bank Groups*			
	C	D	E	cp	li	mi	oe
<u>Africa and Middle East</u>							
All Countries Listed	27	21	52	-	46	40	13
Individual Responses	33	31	36	-	33	38	29
Countries Responding	30	30	41	-	39	39	21
<u>Americas</u>							
All Countries Listed	78	18	4	4	4	92	-
Individual Responses	91	9	0	0	0	100	-
Countries Responding	88	12	0	0	0	100	-
<u>Asia and the Pacific</u>							
All Countries Listed	43	30	27	12	52	36	-
Individual Responses	47	30	23	0	49	51	-
Countries Responding	43	29	28	0	50	50	-
<u>Europe</u>							
All Countries Listed	100	0	0	25	-	75	-
Individual Responses	100	0	0	0	-	100	-
Countries Responding	100	0	0	0	-	100	-
<u>All Developing Countries</u>							
All Countries Listed	45	22	33	4	37	51	8
Individual Responses	59	22	19	0	27	63	10
Countries Responding	52	23	25	0	30	60	10

*cp=centrally planned economy, li=low income, mi=middle income, oe=capital-surplus oil-exporter technologists working in these countries are absent from the overall response.

In a few cases, it was desirable to compare responses from developing countries with responses from the United States or Canada. To facilitate this, "average state responses" and "average province responses" were computed. "Average country responses" from developing countries could then be compared with "average state (or province) responses".

The answers to questions 5 to 12 were descriptive. Therefore, they could not be averaged. In some cases, therefore, analysis of responses was done on an individual basis. When this is done, the inferences made are subject to the biasedness of the sample. However, the use of individual responses was the only way to compare certain responses, and to test the effects of place of employment, level of education, and certain other factors.

To summarize the preceding paragraphs, the responses to the questionnaire are analyzed in one of three forms, depending upon the form of the data and the test being done. The first form is the individual response. The second form is "average country responses" from developing and industrialized (including Canada and the U.S.) nations. The third form is "average country responses" from developing countries and "average state or province responses" from the United States or Canada. The form of data being used will be stated at each step in the analysis.

Respondents

Persons responding to the questionnaire were asked to provide certain information about themselves. This data was their sphere of employment, their level of educational attainment, and whether or not they had received specialized training in the environmental sciences. Table VI.4 summarizes the answers to these three questions. The significance of differences between different geographical regions and levels of development was tested using chi-square test for independence. The input data and results of these tests can be found in Appendix B.

The international questionnaire was sent to technologists known to be involved in environmental affairs in both developing and industrialized nations. There was no prior knowledge of respondents sphere of employment, level of education or specialized environmental training. The overall response may therefore be considered random samples of environmental technologists in developing and in industrialized nations. Working from this premise, certain inferences can be made from the data in Table VI.4 and the statistical test results in Appendix B.

The first set of trends relate to sphere of employment. The three areas of employment are government service, education, and other. This last group included persons employed by industry and those engaged in consulting. All of the differences were found to be statistically significant. Comparing all developing countries with all industrialized countries, it will be noted that in the former group the technologists are concentrated in government and education. In the latter group, the distribution is more equitable. Among the developing

Table VI.4: Respondents to Questionnaire

Note: Data analyzed on an individual response basis.

Region or Group	Percentage of Respondents in Each Category						
	By Employment Sector			By Education		Env. Training?	
	Government	Education	Other	Bachelor's Degree	Graduate Study	Yes	No
DEVELOPING							
Africa and Middle East	42%	51%	7%	33%*	67%	70%	30%
Americas	39%	34%	27%	30%	70%	60%	40%
Asia and the Pacific	52%	27%	21%	25%	75%	56%	44%
Europe	17%	66%	17%	17%	83%	83%	17%
INDUSTRIALIZED							
U.S.A.	40%	24%	36%	15%	85%	67%	33%
Canada	23%	17%	60%	16%	84%	77%	23%
Other Industrialized	38%	36%	26%	6%	94%	82%	18%
All Developing	43%	38%	19%	29%	71%	62%	38%
All Industrialized	36%	27%	37%	12%	88%	74%	26%

*includes one respondent with no University education countries, each of the four groups has its own pattern. In the Americas, the distribution is equitable, with a slight concentration in government and a corresponding deficiency in industry and consulting. In Asia and the Pacific, there is a marked concentration of technologists in government, while in Europe there is an even more marked concentration in education. The situation in Africa and the Middle East is that there is a noticeable deficiency of environmental technologists in industry and consulting.

Although the distribution of technologists that exists in the industrialized nations cannot be shown to be ideal, there is much to be said in favor of an equitable distribution. Each sphere of employment has an important role to play in environmental conservation, and deficiencies in any one area will retard the overall effort. The paucity of numbers in industry and consulting is particularly unfortunate, since it is this group which generally implements action. The reasons for this paucity was not clear either in the literature reviewed or in the comments received. It is possible that the mailing list itself contributed to the bias against industry and consulting. Perhaps the sources used listed a disproportionate number of persons working in government and education. Unfortunately, there was no way to check this.

Two levels of education were considered: Bachelor's Degree and Graduate Study. The differences in the proportion at each level was not significant among the groups of developing countries. However, a significantly higher proportion of technologists in industrialized nations had done graduate study than their counterparts in the third world. The two classes in environmental training were those who had specialized training and those who had not. Again, the differences in the proportion at each level was not significant among the groups of developing countries. But again, a significantly higher proportion of technologists in industrialized countries had received specialized environmental training than those in developing nations.

This situation should not be seen as representing a difference in the quality of human resources between the two groups of countries. Instead, it is reflective of the lack of educational opportunities in the developing world. In fact, many technologists from the third world must travel to the industrialized nations to receive their university education. This is particularly the case in new and technical fields like environmental science.

The need to leave one's country to receive an education may be part of the reason why fewer environmental technologists in the third world work in consulting and industry than in government and education. This has to do with scholarships. Many students do go abroad on scholarships, and most of these agreements contain a "payback" clause. The student is required to serve the financing agency for a specified period after graduation. Since the vast majority of scholarships are awarded by governments, most returning graduates will be assigned to either the government service or government-run universities.

Summary

A total of 158 individuals from 72 developing countries and 150 from 22 industrialized nations responded to the questionnaire. This was a higher response rate than had been anticipated. The responses from developing countries were compared with the distribution of these countries in the McHale's groups and the World Bank groups. In both cases, the distribution of countries responding was found to be the same as the distribution of all developing countries. However, the individual responses were found to be biased, with the more affluent third world countries submitting more responses than the poorer ones. In terms of employment sector, persons in industry and consultancy were less represented in the responses from developing countries than those from industrialized ones. In addition, a smaller proportion of respondents from the third world had done graduate study or received specialized environmental training than their counterparts from industrialized nations.

EIA Legislation and Practice

Table VI.5 summarizes the current status of EIA legislation and practice in developing and industrialized countries. The data was drawn from replies to questions 5 and 6 on the questionnaire.

Legislation

A total of 71 developing countries responded to the question on legislative requirements for EIA. Twenty-one industrialized countries also provided this data. The percentage of these countries which had a legal requirement for EIA on major projects was 54% for developing nations, compared to 76% for industrialized nations. The highest percentage among developing countries were those from Europe, and Asia and the Pacific, with 66%. In the Americas, 57% of the developing

Table VI.5: Current Status of EIA: Legislation and Practice

COUNTRY	EIA LAWS?	EIAs DONE?
DEVELOPING COUNTRIES		
1. AFRICAN AND MIDDLE EAST		
Bahrain	No	Yes
Botswana	Yes	Yes
Burundi	No	Yes
Cameroon	Yes	Yes
Canary Is.	No	Yes
Egypt	No	–[1]
Ethiopia	No	No
Ghana	No	Yes
Iran	Yes	Yes
Iraq	Yes	Yes
Kenya	Yes	Yes
Jordan	Yes	Yes
Kuwait	Yes	–
Liberia	Yes	Yes
Madagascar	No	No
Mauritius	No	–
Mozambique	No	Yes
Nigeria	Yes[2]	Yes
Oman	Yes	Yes
Saudi Arabia	Yes	Yes
Sierra Leone	No	Yes
Somalia	No	–
South Africa	No	Yes
Tanzania	No	Yes
Uganda	No	No
Zaire	No	No
Zambia	–[3]	Yes
2. AMERICAS		
Argentina	Yes	Yes
Bahamas	Yes	–
Barbados	Yes	Yes
Bermuda	No	No
Brazil	Yes	Yes
Cayman Is.	No	Yes
Chile	No	No
Colombia	Yes	Yes
Costa Rica	No	Yes
Dominican Rep.	No	No
Ecuador	Yes	Yes
Guyana	No	–
Mexico	Yes	Yes
Netherland Antilles	No	Yes
Panama	Yes	Yes
Peru	Yes	Yes
Puerto Rico	Yes	Yes
St. Lucia	No	Yes
Suriname	No	Yes
Trinidad and Tobago	No	Yes
Uruguay	Yes	No
Venezuela	Yes	Yes
Virgin Is. (U.S.)	Yes	Yes
3. ASIA AND PACIFIC		
Bangladesh	Yes	Yes
Bhutan	No	Yes
Fiji	–[4]	Yes
French Polynesia	Yes	Yes
Guam	Yes	Yes
India	Yes	Yes
Indonesia	Yes	Yes
Korea (South)	Yes	Yes
Malaysia	No	Yes
Nepal	No	Yes
New Caledonia	Yes	Yes
Pakistan	No	No
Papua New Guinea	Yes	Yes
Philippines	Yes	Yes

[1] only superficial assessments have been done

[2] draft legislation is before Parliament

[3,4] respondents disagreed

Table VI.5 (continued)

COUNTRY	EIS LAWS?	EIAs DONE?	COUNTRY	EIA LAWS?	EIAs DONE?
Sri Lanka	No	Yes	Poland	Yes	Yes
Taiwan	Yes	No	Portugal	No	-[10]
Thailand	Yes	Yes	Spain	-[11]	Yes
U.S. Trust of Pacific Is.	Yes	Yes	Switzerland	Yes	Yes
			United Kingdom	No[12]	Yes
			U.S.A.	Yes[13]	Yes
4. EUROPE			Yugoslavia	No	Yes
Cyprus	Yes	Yes	SUMMARY		
Greenland	Yes	Yes			
Turkey	No	Yes	All Developing Countries	54%	77%
INDUSTRIALIZED NATIONS			All Industrialized Countries	76%	95%
Australia	Yes	Yes	Africa and the Middle East	41%	70%
Belgium	Yes[5]	Yes			
Canada	Yes[6]	Yes	Developing Countries in the Americas	57%	74%
Czechoslovakia	Yes	Yes			
Denmark	No	Yes			
Finland	Yes[7]	Yes	Asia and the Pacific	66%	89%
France	Yes	Yes			
West Germany	Yes	Yes	Developing Countries in Europe	66%	100%
Greece	Yes	Yes			
Holland	Yes	Yes			
Ireland	Yes	Yes			
Japan	Yes[8]	Yes			
Luxemburg	Yes	Yes			
Norway	Yes[9]	Yes			

[5]legislation in preparation

[6]at Provincial level

[7]at local government level

[8]at local government level

[9]legislation is proposed

[10]respondents disagreed

[11]respondents disagreed

[12]EIA is part of planning approval process

[13]at Federal level

countries that reported had legal requirements for EIA. The countries of Africa and the Middle East had the lowest figure, with 41%.

Practice

A greater percentage of the reporting countries had conducted EIAs than had laws requiring it: 77% of the developing and 95% of industrialized nations. Only Uruguay and Taiwan reported that they had laws but had not actually done any EIAs. On the other hand, many of the nations that had no legal requirement had in fact done EIAs, usually to comply with the requirements of international lending agencies. Of the developing countries, all those reporting from Europe had conducted environmental assessments, 89% from Asia and the Pacific, 74% from the Americas, and 70% from Africa and the Middle East. This contrasts with 95% for the industrialized nations.

Summary

The practice of assesing the environmental effects of major projects is now widespread in developing countries, and nearly universal in industrialized nations. The enactment of legislation requiring such assessments has been slower. Among developing countries, the regions of Europe and Asia and the Pacific have the highest proportion of nations that legally require EIA, as well as the highest proportion actually conducting assessments. The region with the lowest proportion of nations with a legal requirement for EIA is Africa and the Middle East. This region also has the lowest proportion of countries that conduct assessments.

The Need for EIA

This section deals with how respondents perceived the need for EIA in their own countries. Questions 7, 8 and 9 asked about the adequacy of current efforts to protect the environment, the need for EIA, and the sufficiency of trained technologists to conduct EIA. The replies to these questions are analyzed in this section. The responses, expressed as percentages, are summarized in Table VI.6.

Present Efforts

A majority of the respondents felt that present efforts to protect their country's environment were inadequate. However, the proportion expressing this view was significantly larger in developing countries (88%) than in industrialized countries (55%). Among developing countries, the differences between geographical regions were not significant. In the industrialized world, only respondents from the United States expressed a majority view that present efforts were adequate. In Canada, the proportion who felt that present efforts were inadequate approached the level in developing countries.

In the responses from the third world, the proportion expressing dissatisfaction with present efforts was independent of respondent's sector of employment, level of educational attainment, or exposure to specialized environmental training. It was also independent of whether or not EIAs had been conducted in the respondents country. However, it was dependent on whether laws requiring EIA had been enacted in the respondent's country. Although

Table VI.6: The Need for EIA

Note: Data analyzed on an individual response basis.

Region or Group	Percentage of Respondents Giving Each Answer					
	Present Efforts Adequate?		Is EIA Now Necessary?		Are Experts Available?	
	Yes	No	Yes	No	Yes	No
DEVELOPING						
Africa and the Middle East	13%	87%	98%	2%	27%	73%
Americas	10%	90%	95%	5%	54%	46%
Asia and the Pacific	12%	88%	98%	2%	25%	75%
Europe	20%	80%	100%	0%	50%	50%
INDUSTRIALIZED						
United States	56%	44%	97%	3%	90%	10%
Canada	25%	75%	100%	0%	76%	24%
Other	42%	57%	94%	6%	63%	37%
All Developing	12%	88%	97%	3%	37%	63%
All Industrialized	45%	55%	96%	4%	77%	23%

the majority expressed dissatisfaction in both cases, a larger minority expressed satisfaction where laws existed than where they did not.

The responses to this question were as expected. The awareness of environmental problems has been slower in arriving in developing nations than in industrialized ones. Hence, the response to these problems has been slower in the former than the latter. What is interesting in comparing the two groups is that even in industrialized countries, respondents were not satisfied that efforts were adequate. The sole exception was the United States.

The importance which third world respondents attached to EIA legislation, as distinct from EIA practice, is also worthy of comment. It would appear that respondents feel that only voluntary assessments or assessments requested by international agencies would not be enough. Instead, a clear set of legally enforceable standards is desirable. In fact, this was noted by one respondent in his miscellaneous comments. This technologist emphasized the need for laws stipulating when an EIA was necessary as well as environmental quality standards.

Assuming, then, that environmental laws are deemed desirable in developing countries, there are three models which may be considered. In the United States, policy-making and enforcement are concentrated at the federal level. The benefit of this model is uniformity in environmental efforts. This approach was judged adequate by a little more than half of the respondents from the U.S. The Canadian model is based on general guidance from the federal government and policy-making and enforcement at the provincial level. The benefit here is that policies can be formed based on local values and perceptions. Rather surprisingly, this approach received a very low approval rating among Canadian respondents. The third system is still being formulated in Europe. The approach being tried is integration of EIA into their already elaborate planning approval processes. Though still in its infancy, this model was approved by somewhat less than half of the respondents from Europe. When comparing these three alternatives, each developing country must consider which, if any, would best fit into its own political and economic system. Where none are found to be suitable, it would be necessary and desirable to develop a new model.

The Need for EIA

There was an overwhelming sentiment that EIA was necessary. The number of negative responses received was in fact so low that the chi-square test was inappropriate. Responses were categorized by level of development, geographical region, employment sector, level of education and specialized environmental training. In all cases, the proportion was the same: 94% to 100% of respondents felt that EIA was necessary in their country.

This large response in favor of EIA is reflective of the expectations that technologists have of the process. Based on this survey, it might be inferred that the technical sector in the third world would encourage the implementation of EIA in their countries. Whether or not this inference is accepted depends upon the interpretation of non-responses to the survey. If those who responded are a representative sample of those who received the questionnaire, then the overwhelming support of EIA is typical of environmental technologists in the third world. On the other hand, if those who are interested in EIA responded, and those who are not did not, then the results are biased. It is logical to assume that those who are not interested in EIA would be less likely to respond. Therefore, some bias in the results should be assumed.

Even if the overwhelming support of EIA is assumed to be representative of technologists' attitudes in the third world, a word of caution is offered. Environmental impact assessment is simply a planning tool. Its success as a means of balancing development will depend on its users. If technologists and politicians are not sincere in the desire to balance conservation and development, then EIA will be an exercise in futility, and an expensive one at that.

Availability of Experts

One of the most commonly cited problems in developing countries is the lack of trained personnel. Question 9 addressed this problem with reference to environmental impact assessment. The effect of level of development was clearly evident. Only a third of respondents from the developing world felt that there were enough experts in their countries. In contrast, three-quarters of respondents from industrialized areas felt that their nations had sufficient environmental technologists. This is probably reflective of the situation for all technologists, not just environmental technologists.

Examining the responses from developing countries, a regional trend is apparent. Respondents from the developing countries of America and Europe were divided half-and-half as to whether there were sufficient environmental technologists in their countries. On the other hand, three-quarters of respondents from Africa and the Middle East, and Asia and the Pacific, felt that the available number of technologists was inadequate. These responses were independent of employment, education or environmental training. What is being seen here is the effects of physical proximity and influence of industrialized nations on the third world. The developing areas of Europe and the Americas are heavily influenced by their industrialized neighbors. As a result, these countries have benefited from educational opportunities in industrialized Europe, Canada and the United States. The other developing regions, being further removed from and less influenced by these centers of environmental research, have not been able to build up their pool of experts.

Summary

There was general dissatisfaction with current efforts to protect the environment in both developing and industrialized areas. This feeling was particularly marked in the third world. There was also an overwhelming sentiment in favor of EIA in all countries. As expected, respondents from industrialized areas felt that there were sufficient trained technologists in their countries to conduct EIAs. However, those from developing countries felt that sufficient experts were not available.

EIA Cost and National Development

Two objections to EIA that are commonly voiced are that the cost is prohibitive and that the practice retards development.

Questions 10, 11 and 12 were included to determine how environmental technologists view these objections. The responses are analyzed statistically in Appendix B, and discussed in the following paragraphs. As explained in the appendix, it was necessary to group the responses "no effect" and "decrease" in question 10, and "no effect" and "retard" in questions 11 and 12. This was necessary to accommodate the "rule of thumb" that no cell in the chi-square contingency table should have an expected value of less than 5. In fact, the revised categories are not purely arbitrary. If the implementation of EIA increases the cost of projects, then a country must decide whether this cost is justified. On the other hand, if EIA has no effect on cost, or if it reduces cost, then the process is highly advisable. Similarly, if EIA enhances national development or project planning, it would be very attractive. But if it has no effect, or retards development or planning, then benefit/cost considerations must be made.

Cost of EIA

In the questionnaire, the term "project cost" was intended to mean the financial outlay for a project. A few respondents commented that "project cost" could be construed to include social and environmental costs as well. However, all those who made this point indicated that they had answered that respondents generally interpreted "project cost" as financial outlay.

The majority opinion among all respondents was that EIA increases the cost of projects (see Table VI.7). The proportion of technologists expressing this view was found to be independent of level

Table VI.7: EIA Cost and National Development

Note: Data analyzed on an individual response basis.

Region or Group	Percentage of Respondents Giving Each Answer					
	Effect of EIA on Project Cost		Effect of EIA on National Development		Effect of EIA on Project Planning	
	Increase	No Effect /Decrease	Enhance	No Effect /Retard	Enhance	No Effect /Retard
DEVELOPING:						
Africa and the Middle East	84%	16%	79%	21%	80%	20%
Americas	71%	29%	88%	12%	81%	19%
Asia and the Pacific	83%	17%	60%	40%	78%	22%
Europe	100%	0%	20%	80%	33%	66%
INDUSTRIALIZED:						
United States	75%	20%	41%	59%	71%	29%
Canada	70%	30%	44%	56%	70%	30%
Europe	63%	34%	41%	59%	57%	43%
ALL DEVELOPING	80%	20%	74%	26%	78%	22%
ALL INDUSTRIALIZED	70%	30%	42%	58%	66%	34%

of development and geographical region. Among the answers from the third world, the proportion was also independent of respondents' employment and educational level. There was some indication that a smaller proportion of persons who had specialized environmental training felt that EIA increased project cost than those who had not had such training. However, this trend was not very pronounced.

The general perception that EIA increases project (financial) cost is a realistic one. The cost of project design is increased because of the special studies which must be undertaken. The cost of project construction goes up because of the mitigation measures which are incorporated. Thus, the amount of cash required to implement a project is greater. But this added cost does bring benefits, as indicated in Chapter II. The social, economic and other environmental benefits of a balanced design must be weighed against the increased cost in order to determine whether EIA is a net gain or a net loss.

Table VI.8 shows the relationship between respondents perceptions of the cost of and need for EIA. Because the cells were so sparse, the chi-square analysis was inappropriate. However, even without the benefit of that statistical test, one trend is evident. In developing countries, as in all countries, a sizable majority felt that EIA is necessary, even though they acknowledge that it will increase project costs. This indicates that the majority of respondents believe that EIA is a net gain. However, a much better documented case must be presented if politicians and industrialists are to be convinced that this is the case.

Table VI.8: The Cost of and Need for EIA

A. <u>All Respondents</u>:

How will EIA affect project cost?

Is EIA Necessary?	Increase	No Effect	Decrease
YES	183(72.3%)	44(17.4%)	16(6.3%)
NO	7(2.8%)	2(0.8%)	1(0.4%)

B. <u>Respondents from Developing Countries</u>

How will EIA affect project cost?

Is EIA Necessary?	Increase	No Effect	Decrease
YES	107(77.0%)	20(14.4%)	7(5.0%)
NO	3(2.2%)	1(0.7%)	1(0.7%)

EIA and National Development

The responses regarding EIA and national development are summarized as percentages in Table VI.7. Differences between the two levels of development and those among the geographical regions of the third world were found to be significant. A majority of respondents from industrialized nations felt that EIA either did not affect or retarded national development. In contrast, the majority of third world respondents felt that EIA would enhance development. The third world responses were independent of employment and specialized environmental training. However, it was found that a larger proportion of respondents who had done graduate studies felt that EIA would not affect or would retard development than those with only bachelor's degrees.

The differences in response to this question appears to be based on the difference between theory and practice. Respondents from industrialized nations will have seen several EIAs conducted, and probably based their answers on the actual results noted. Third world respondents, on the other hand, will have seen only a few, if any, EIAs conducted. Thus, their answers are probably based on the theoretical concepts involved: what EIA can or should do.

The same holds for the geographical regions of the third world. It was shown in an earlier section of this chapter that Asia and the Pacific was more "progressive" than the Americas or Africa and the Middle East in terms of laws enacted and experience with EIA. Thus, a larger proportion of environmental technologists from Asia and the Pacific would have seen EIAs conducted. A larger proportion of respondents from this region felt that EIA would have no effect on or retard development than those from the Americas or Africa and the Middle East.

Another probable reason for the differences in response from developing and industrialized countries has to do with level of technology. In the industrialized areas, environmental standards are more stringent, and industrial output is more noxious. Thus, the degree of environmental protection that is required is greater, using a higher level of technology and costing more. The environmental study highlights the need for such protection. Thus, the costs and delays associated with these protective measures tend to be attributed to the EIA.

The effect of level of educational attainment is less clear-cut, but the argument on theory and practice probably holds. A larger proportion of graduate degrees in the developing countries are earned in industrialized nations, while a smaller proportion of bachelor's degrees are earned in the industrialized world. Therefore, third world respondents who have done graduate studies are more likely to reflect metropolitan values than their counterparts with bachelor's degrees.

EIA and Project Planning

In question 12, respondents were asked how EIA would affect project planning. As with EIA and national development, the choices of answers were enhance, no effect and retard. The answers received are summarized as percentages in Table VI.7. In general, the majority of respondents felt that EIA would enhance project planning.

In response to this question, differences between developing and industrialized areas were significant. In both cases, a majority felt that project planning would be improved. However, the actual percentage expressing this opinion was greater in responses from the third world than in responses from the industrialized nations. In contrast, differences among the responses from the several geographical regions within the third world were not found to be significant.

Among responses from the developing countries, the proportion who felt that EIA would enhance project planning was found to be independent of respondent's sector of employment and education. However, there was some degree of dependence upon whether or not the respondent had received environmental training. The proportion who felt that EIA would enhance project planning was larger among those who had received such training than among those who had not. As was the case with EIA cost, though, this trend was not very pronounced.

Environmental impact assessment is a planning tool. Therefore, the majority belief that it will enhance project planning is not surprising. What is strange is that a smaller majority espouse this view in industrialized countries than in developing ones. Again, this may be because technologists in developing countries are commenting on EIA as it should be (theory), and those from industrialized nations are commenting on EIA as it is (practice). Thus, the level of skepticism is greater among the latter than the former.

Summary

There was a majority belief in all countries that EIA would increase project costs. However, this realization did not sway the opinion that EIA was necessary in both developing and industrialized areas. Opinion was divided on the effect of EIA on national development. The majority in industrialized nations felt that it would have no effect on or retard development. The majority in the third world felt that EIA would enhance development. This majority was greatest in Africa and the Middle East as well as the Americas, and smallest in Asia and the Pacific. Finally, the majority of respondents from all countries felt that EIA would enhance project planning. The proportion expressing this opinion was greater in the third world than in industrialized nations.

Importance of Environmental Parameters

In Part 3 of the questionnaire, respondents were asked to rate the importance of changes in each of 18 environmental parameters. Seven of these parameters came from the physical-chemical environment, 5 from the biological, 3 from the socio-economic and 3 from the cultural. The objective was two-fold. The first was to gain some insight as to how each parameter was viewed in different regions and at different levels of development. The second objective was to compare the importance rating of parameters from different environmental components in a given region.

Before proceeding to discuss the results of this part of the questionnaire, there is one general comment which must be addressed.

Several respondents (24 in number) indicated that the parameters in this section were too general to rate reliably. Some went on to explain that the importance of a particular parameter is project-specific, and that an importance rating would have to relate to a particular action. Persons making this comment came from both developing and industrialized areas. Roughly half of those who made this comment did assign importance ratings to the environmental parameters, while the rest did not.

The comment described in the last paragraph is a valid one. Parameter importance does tend to be project specific, and as a result generalization may be difficult. However, this does not totally invalidate the use of the data generated in this part of the questionnaire. The key issue here is the use to which the data is being put. If the objective were to design a weighting checklist, for example, then the responses to this questionnaire would probably be inadequate. But these responses are being used only to gauge differences in perception between different levels of development and different geographical regions. For this purpose, the ratings received are reasonably valid.

The statistical analysis is summarized in Appendix B, and the results are discussed in this section. The test used was the Kruskal-Wallis, and the data was in the form of country responses. For convenience, the data that is tabulated in this section has been further summarized into average regional importance ratings. This was done to reduce the number of tables, as well as to sharpen the contrast between regional responses. It must be noted, however, that the statistical test did not utilize these regional averages.

Physical-Chemical Parameters

The first seven parameters in the list came from the physical-chemical environment. Two related to surface fresh water, two to the atmosphere, two to the terrestrial environment and one to the marine. Categorized in another way, three are usually associated with the impacts of heavy industry and the other four with more general development. It was found that the responses conformed to the second set of categories rather than the first. The three parameters generally associated with heavy industry were temperature in streams, sulfur dioxide in the atmosphere and visibility (presence of smoke and photochemical smog). The other physical-chemical parameters were suspended solids in streams, changes in topography of land, dissolved solids in ground water and salinity in marine and estuarine waters.

Parameters Associated with Heavy Industry: The ratings of these three parameters showed common trends. Differences in ratings among the countries of the third world were not significant. However, differences between developing and industrialized nations were always significant at the $\alpha = 0.05$ level, with the latter group assigning higher ratings than the former (see Table VI.9). The first reason for this is the immediacy of the problem. Technologists in the industrialized regions probably have first hand experience with the problems of thermal discharges, sulfur dioxide and photochemical smog.

Table VI.9: Physical-Chemical Parameters Associated with Heavy Industry

Note: Regional average is the mean of county, state or provincial average.

Region	Average Regional Importance Rating*		
	Temp. in Streams	SO_2 in Atmos.	Visibility (Smoke and Smog)
<u>Developing</u>			
Africa and Middle East	1.30	2.46	1.86
Americas	1.68	2.73	2.30
Asia and Pacific	1.65	2.63	2.35
Europe	1.33	2.00	2.33
<u>Industrialized</u>			
United States	3.39	3.97	3.46
Canada	3.00	4.14	3.29
Other Industralized	2.74	4.00	2.95

* Importance Scale: 0 = Unimportant, ignore this factor

1 = Marginally important

2 = Moderate importance

3 = Average importance

4 = Very important

5 = Extremely important

As a result, they are more aware of the effects of these impacts. Hence, their ratings were higher.

In addition to familiarity with the problem, there are also more specific reasons why these parameters received higher importance ratings in industrialized nations. The first relates to thermal discharges. It was shown in Chapter III that the majority of the third world is situated in the tropical zone, while most of industrialized nations are in the temperate zone. Thermal discharges tend to produce more marked secondary effects in temperate regions than in the tropics. For example, a hot water discharge during winter can cause premature melting of ice and may upset the annual cycle of certain plants and animals. While thermal discharges do cause impacts on tropical climates, they are generally not as dramatic as those in colder regions. Therefore, the response received is consistent with the geographical distribution of nations at different levels of development.

The final reason for the dichotomy in responses relates to both sulfur dioxide and photochemical smog pollution. The picture which is commonly used to typify air pollution shows factory smokestacks belching forth pollutants into the atmosphere. In fact, this perception of the cause of air pollution may be erroneous. Studies have shown that automobile emissions are the major source of contaminants in many cases (Rau and Wooten, 1980). However, the concentration of factories and automobiles is greater in the industrialized world than in the developing countries. Thus, whether the cause of air pollution is factories or cars, the problem is more acute in industrialized areas. The response received is consistent with this fact.

Parameters Related to General Development: The differences in responses from developing countries were again not significant. In these parameters, the differences between industrialized and developing areas were not as consistent as before. Because of this, each parameter will be discussed separately.

The concentration of suspended solids in a stream depends upon a host of factors, some natural and others man-made. Sources of suspended solids may be point or non-point. The former includes outfalls from industry and municipal sewage treatment plants. The latter includes soil erosion and municipal run-off. As a result, problems associated with suspended solids in streams are experienced in both developing and industrialized regions.

The average regional importance ratings for suspended solids in streams is shown in Table VI.10. The importance attached to this parameter in the United States and Canada is higher than in the third world. The reason for this difference probably has to do with the fact that these industrialized countries are now using more and more expensive methods to satisfy their demand for industrial, domestic and agricultural water. On the other hand, many developing countries are still using relatively inexpensive treatment methods. Thus, the importance of contaminating water supply sources is considered greater in industrialized countries.

In addition to surface water, ground water is also used as a source of supply. The dissolved solids concentration can also come

Table VI.10: Physical-Chemical Parameters Associated with General Development

Note: Regional average is the mean of country, state or provincial averages.

Region	Average Regional Importance Rating*			
	S.S. in Streams	Changes in Land Topography	T.D.S. in Ground Water	Salinity in Seas and Estuaries
Developing:				
Africa and Middle East	2.81	2.67	2.75	2.43
Americas	2.95	3.13	2.55	2.26
Asia and Pacific	3.24	2.88	2.76	2.65
Europe	2.33	2.33	2.67	2.33
Industrialized:				
United States	3.89	2.61	3.51	2.95
Canada	3.57	2.57	3.43	2.71
Other Industrialized	3.26	3.26	3.53	2.22

*Importance Scale: See Table VI.9

from either natural or man-made sources. Among the latter are infiltration from agricultural activity and leachate from landfills and dumps. Pollution of ground water is far less obvious than surface water contamination, because it is hidden from view. Thus, it goes largely undetected until water from the aquifer is pumped out for some use. It can be seen in Table VI.10 that this parameter received a higher rating in the industrialized nations than third world. One reason for this is that far more testing of aquifers has been conducted in industrialized areas, hence awareness of the problem is greater. Another reason is the cost of producing sufficient water to satisfy a country's needs, as discussed in the last paragraph.

The last two physical parameters were the topography of land and the salinity in seas and estuaries. As seen in Table VI.10 and in Appendix B, the differences between regions and levels of development were not significant. These two parameters are the most general of the physical-chemical group. Changes in land topography can result from urban development, terracing for agriculture or some mining activities. Micro- and mesoscale reductions in the salinity of estuaries or coastal areas usually results from increased runoff due to changes in ground cover. These types of activities are fairly common in both developing and industrialized areas, hence the uniformity of the importance ratings.

Biological Parameters

Respondents were asked to rate the importance of five biological parameters, and their answers are summarized as regional averages in Table VI.11. The statistical tests are shown in Appendix B. A discussion of each of the biological parameters is contained in the following paragraphs.

The natural vegetation in an area is removed to make room for urban development, industry or agriculture. This displacement process has been experienced on a fairly large scale in both industrialized and developing countries. In rating this parameter, respondents from all regions and levels of development uniformly acknowledged that replacement of natural vegetation is an impact of average importance.

Highways, transmission lines, pipelines and reservoirs are some of the projects which can obstruct the migration routes of animals. The rating of this parameter showed differences based on geographical region, but not level of development. Respondents from the United States and Canada rated this impact as being of average importance. Those from industrialized Europe and the developing countries rated it as having only moderate importance. In North America, there are still many tracts of wilderness areas, and some species still maintain a migratory cycle. These cycles have been studied and mapped, so there is an awareness of the problems which would arise from obstruction of these routes. Thus, the ratings are higher. In the developing regions, the presence and importance of migratory routes is less well-established. Also, a larger proportion of these countries is still in a natural state. Hence, the perception is that alternative routes are available if present ones are obstructed. In Europe, the situation is different. Because the land has been farmed and settled for many centuries, the remaining species have adapted to co-existence with man.

Table VI.11: Biological Parameters

Note: Regional average is the mean of country, state or provincial averages.

Region	Average Regional Importance Rating*				
	Natural Vegetation	Animal Migration Routes	Species Diversity	Species Number	Endangered Species
<u>Developing</u>:					
Africa and Middle East	3.61	2.14	2.61	2.78	3.11
Americas	3.64	2.05	3.96	3.68	4.00
Asia and Pacific	3.59	1.76	3.12	3.35	3.65
Europe	3.00	2.00	2.67	3.00	3.33
<u>Industrialized</u>:					
United States	3.29	3.00	3.51	3.24	4.26
Canada	2.86	3.57	3.14	3.14	4.14
Other Industrialized	3.37	2.00	3.32	3.05	3.89

*Rating Scale: See Table VI.9

Therefore, the obstruction of migration routes is a relatively rare occurrence.

Species diversity is an indicator of the stability of an ecosystem (Odum, 1971). As a result, a reduction in species diversity reduces the stability of the affected ecosystem. Reduction in species diversity was rated as very important in the United States and the developing American countries, and of moderate or average importance in all other countries. The reason for these ratings is not clear. It does show the influence of the United States on technology in adjacent developing countries. But that influence alone does not explain the high ratings given by the developing nations in the Americas.

A reduction in population size can transform a vibrant species into a threatened or endangered condition. Such an impact is generally recognized as being of average importance. This perception is unaffected by geographical region or level of development.

If a species is rare or endangered, further depletion would result in extinction. Impacts on rare or endangered species are rated between very and extremely important in the Americas, and between average and very important in other countries. This may be a result of the activities of environmental groups such as the Sierra Club and the Audubon Society. The largest and most active of these groups are all headquartered in the Western Hemisphere. In contrast, the groups in Asia and the Pacific, Africa and the Middle East and Europe appear to gain far less public attention.

Socio-Economic Parameters

Three socio-economic parameters were included in the questionnaire: employment, reduced food imports and health effects. The average regional importance rating of each parameter is presented in Table VI.12, and the statistical test results are given in Appendix B. These results are discussed in the following paragraphs.

All countries rated employment impacts as either average or very important. The responses were uniform, regardless of geographical region or level of development. This is reflective of the harsh economic climate which now prevails worldwide.

The ratings of reduced food imports were exactly as expected. The answers from developing countries were uniform, and this impact was seen as having average importance. In contrast, the responses from industrialized nations were all lower, and the impact was considered only moderately important. This is a direct result of the international food situation. The large food exporters are generally industrialized, while most of the third world imports food. Hence, the importance of reducing food imports is much greater in the latter group.

All countries rated health effects of projects as very important. There were no trends based on geographical region or level of development. This is as expected. Most large development projects undertaken by governments are intended to improve the quality of life in the country. Good health is an important aspect of the quality of life. Hence, impacts on community health are very important in all countries, regardless of whether they are beneficial or adverse.

Table VI.12: Socio-Economic Parameters

Note: Average regional rating is the mean of county, state or province ratings

Region	Average Regional Importance Rating*		
	Employment	Reduced Food Imports	Health Effects
Developing:			
Africa and Middle East	3.63	3.36	4.18
Americas	3.64	2.73	4.09
Asia and Pacific	3.53	3.24	4.18
Europe	2.67	2.33	4.00
Industrialized:			
United States	3.47	1.86	4.37
Canada	4.00	1.14	4.43
Other Industrialized	3.05	1.68	4.42

*Importance Scale: See Table VI.9

Cultural Parameters

The last three parameters in the questionnaire were chosen from the cultural environment. Respondents were asked to rate the importance of impacts upon archaeological sites, scenic areas and religious practices. The average regional importance ratings are given in Table VI.13, and the statistical test results are summarized in Appendix B.

In general, impacts involving archaeological sites were rated as having average importance. Differences based on level of development were not significant. When the four developing areas were compared, there was some evidence of significant differences. Ratings from the developing areas of Europe were somewhat higher (in the region of very important). Those from Africa and the Middle East were a little lower (at the level of moderate importance). However, these tendencies were not marked.

One possible explanation for the somewhat lower importance rating in Africa is the lack of emphasis on the historical development of this continent. The history books which are studied in developing countries were written mostly in Europe, though recently some have been authored in North America. To a large extent, these books have emphasized China, India, and the Mediterranean basin as the "cradles of civilization". Little attention was paid to sub-Saharan Africa. More recently, some scholarly activity has been focused on the pre-Columbian civilizations of North, Central and South America, and the early settlements of the Pacific Islands. Still, not much is being written about Africa. As a result, there may be a tendency to consider the

Table VI.13: Cultural Parameters

Note: Average regional rating is the mean of country, state or province ratings

Region	Average Regional Importance Rating*		
	Archaeological Sites	Scenic Areas	Religious Practices
Developing:			
Africa and Middle East	2.46	2.96	1.93
Americas	3.09	3.65	1.64
Asia and Pacific	3.18	3.29	3.29
Europe	4.33	2.33	2.00
Industrialized:			
United States	3.40	3.26	1.76
Canada	3.14	3.29	1.57
Other Industrialized	3.26	3.21	0.95

*Importance Scale: See Table VI.9

archaeology of Africa as relatively unimportant. This explanation is supported by the fact that respondents from Egypt and a few of the Arab states rated archaeological sites as very important or extremely important. In fact, this area is the one section of the region which has been the subject of extensive archaeological investigations.

Impacts on scenic areas were rated as having average importance, regardless of a country's geographical region or level of development. Impacts on religious practices received a generally low rating. This parameter was rated as being of marginal or moderate importance in all but one region/development-level group. The single exception was Asia and the Pacific, where the rating was average importance. The only religions which are widespread in Asia and the Pacific but not in other groups are Buddhism and Hinduism. The other major religions, Christianity and Islam are also widespread in Asia and the Pacific, but these are also widely practiced in other regions. It may be that the structure of Buddhism and Hinduism make them more suceptible to impacts from development projects, such as the loss of special sites. On the other hand, it may be that respondents in other regions simply do not perceive development projects as having any impact on religious practices.

Environmental Priorities

In addition to the comparison of importance ratings of particular parameters between different regions, it is also instructive to consider whether specific regions consider some aspects of the environment to be more important than others. For example, do the countries of the Americas consider cultural parameters to be more important than physical-chemical ones? A series of Kruskal-Wallis tests were conducted to seek out such priorities. The results of these tests are contained in Appendix B.

Eighteen average parameter ratings for each of the four developing regions are listed in Tables VI.14 to VI.17. In each table, the parameters are grouped by environmental sector. In responses from Africa and the Middle East, there was some evidence that socio-economic parameters were considered to be more important than other parameters. The same held true for responses from Asia and the Pacific. In neither case was the tendency very marked. Responses from the Americas and from Europe showed no indication that any group of parameters is considered more important than others. For comparison, the results from industrialized areas were also tested (see Table VI.18). Again, there was no indication that any one aspect of the environment is considered more important than the others.

The results relating to environmental priorities were quite surprising. The concensus of opinion in the literature reviewed was that developing countries considered socio-economic impacts to be of over-riding importance. This was attributed to the unfulfilled basic needs in these areas. In fact, such a tendency was noted only in Africa and the Middle East and Asia and the Pacific. Note that these two regions contain most of the world's poorest countries. And even in these regions the evidence was not very strong. It would appear, therefore, that persons doing environmental work in the third world maintain a balanced view of the environment in spite of existing

Table VI.14: Environmental Priorities: Africa and Middle East

Note: Average regional rating = mean of country ratings

Parameter	Avg. Regional Rating*
1. Physical-Chemical:	
Suspended solids in streams	2.81
Temperature in streams	1.30
Sulfur dioxide in atmosphere	2.46
Visibility (presence of smoke and smog)	1.86
Changes in topography of land	2.67
Dissolved solids in ground water	2.75
Salinity in marine and estuarine waters	2.43
2. Biological:	
Replacement of natural vegetation	3.61
Obstruction of animal migration routes	2.14
Reduction of terrestrial or aquatic species diversity	2.61
Reduction in numbers of a given species	2.78
Rare of endangered species	3.11
3. Socio-Economic:	
Employment	3.63
Reduced food imports	3.36
Health effects	4.18
4. Cultural:	
Archaeological sites	2.46
Scenic areas	2.96
Effects on religious practices	1.93

*Rating Scale: 0 = Unimportant, ignore factor; 1 = Marginally Important; 2 = Moderate Importance; 3 = Average Importance; 4 = Very Important; 5 = Extremely Important.

Table VI.15: Environmental Priorities: Developing Americas

Note: Average regional rating = mean of country ratings

Parameter	Avg. Regional Rating*
1. Physical-Chemical:	
Suspended solids in streams	2.95
Temperature in streams	1.68
Sulfur dioxide in atmosphere	2.73
Visibility (pressence of smoke and smog)	2.30
Changes in topography of land	3.13
Dissolved solids in ground water	2.55
Salinity in marine and estuarine waters	2.26
2. Biological:	
Replacement of natural vegetation	3.64
Obstruction of animal migration routes	2.05
Reduction of terrestrial or aquatic species diversity	3.96
Reduction in numbers of a given species	3.68
Rare or endangered species	4.00
3. Socio-Economic:	
Employment	3.64
Reduced food imports	2.73
Health effects	4.09
4. Cultural:	
Archaeological sites	3.09
Scenic areas	3.65
Effects on religious practices	1.64

*Rating Scale: See Table VI.14.

Table VI.16: Environmental Priorities: Asia and Pacific

Note: Average Regional rating = mean of country ratings.

Parameter	Avg. Regional Rating*
1. Physical-Chemical:	
Suspended solids in streams	3.24
Temperature in streams	1.65
Sulfur dioxide in atmosphere	2.63
Visibility (presence of smoke and smog)	2.35
Changes in topography of land	2.88
Dissolved solids in ground water	2.76
Salinity in marine and estuarine waters	2.65
2. Biological:	
Replacement of natural vegetation	3.59
Obstruction of animal migration routes	1.76
Reduction of terrestrial or aquatic species diversity	3.12
Reduction in numbers of a given species	3.35
Rare or endangered species	3.65
3. Socio-Economic:	
Employment	3.53
Reduced food imports	3.24
Health effects	4.18
4. Cultural:	
Archaeological sites	3.18
Scenic areas	3.29
Effects on religious practices	3.29

*Rating Scale: See Table VI.14.

Table VI.17: Environmental Priorities: Developing Europe

Note: Average Regional rating = mean of country ratings.

Parameter	Avg. Regional Rating*
1. Physical-Chemical:	
Suspended solids in streams	2.33
Temperature in streams	1.33
Sulfur dioxide in atmosphere	2.00
Visibility (presence of smoke and smog)	2.33
Changes in topography of land	2.33
Dissolved solids in ground water	2.67
Salinity in marine and estuarine waters	2.33
2. Biological:	
Replacement of natural vegetation	3.00
Obstruction of animal migration routes	2.00
Reduction of terrestrial or aquatic species diversity	2.67
Reduction in numbers of a given species	3.00
Rare or endangered species	3.33
3. Socio-Economic:	
Employment	2.67
Reduced food imports	2.33
Health effects	4.00
4. Cultural:	
Archaeological sites	4.33
Scenic areas	2.33
Effects on religious practices	2.00

*Rating Scale: See Table VI.14.

Table VI.18: Environmental Priorities: Industrialized Nations

Note: Average regional rating = mean of country, state or province ratings.

Parameter	Average Regional Rating*		
	U.S.	CANADA	OTHER
1. Physical-Chemical:			
Suspended Solids in Streams	3.89	3.57	3.26
Temperature in Streams	3.39	3.00	2.74
Sulfur Dioxide in Atmosphere	3.97	4.14	4.00
Visibility (Presence of Smoke & Smog)	3.46	3.29	2.95
Changes in Topography of Land	2.61	2.57	3.26
Dissolved Solids in Ground Water	3.51	3.43	3.53
Salinity in Marine and Estuarine Waters	2.95	2.71	2.22
2. Biological:			
Replacement of Natural Vegetation	3.29	2.86	3.37
Obstruction of Animal Migration Routes	3.00	3.57	2.00
Reduction of Species Diversity	3.51	3.14	3.32
Reduction in Numbers of a Given Species	3.24	3.14	3.05
Rare or Endangered Species	4.26	4.14	3.89
3. Socio-Economic:			
Employment	3.47	4.00	3.05
Reduced Food Imports	1.86	1.14	1.68
Health Effects	4.37	4.43	4.42
4. Cultural:			
Archaeological Sites	3.40	3.14	3.26
Scenic Areas	3.26	3.29	3.21
Effects on Religious Practices	1.76	1.57	0.95

*Rating Scale: See Table VI.14

conditions. A similar balanced view was also noted among the responses from the industrialized countries. It is important to note that these responses are representative only of environmental technologists. A similar poll of political leaders, say, will almost certainly yield different results.

Summary

The rating of environmental parameters was found to depend upon a host of factors, some of which were quite specific. However, several relationships were noted among the responses received.

a) In general, respondents assigned higher ratings to parameters with which they perceived as being more immediately threatening to their environment. Those which are not currently associated with problems in the respondent's country were rated as less important.

b) Respondents from developing countries assigned lower ratings to physical parameters than did those from industrialized countries. However, differences in the ratings of physical parameters from different regions of the third world were not significant.

c) The rating of biological parameters bore no relationship to countries' level of development. However, specific geographical regions rated particular parameters higher than others.

d) The rating of socio-economic parameters was uniform among the developing countries.

e) The rating of cultural parameters varied with both geographical region and level of development.

f) Respondents had a balanced perception of the importance of different aspects of the environment. Only in Africa and the Middle East and in Asia and the Pacific was there a mild tendency to rate socio-economic parameters more important than others.

In Part 4 of the questionnaire, respondents were asked to rate the importance of a series of nine criteria. The answers to questions will be discussed in Chapters VII, VIII and IX. The remainder of this chapter will be devoted to discussing the general comments which were received and presenting a conceptual framework for conducting EIA in the third world.

General Comments Received

In Part 5 of the questionnaire, respondents were invited to include additional comments on EIA. In addition, several persons who did not complete the questionnaire included comments in their letters. In this section, these general comments will be presented. For convenience, they will be separated into two groups: comments about EIA, and comments about the questionnaire. A third group are those who did not feel themselves equipped to answer the questions. Of those who wrote to say this, the majority supplied the names and addresses of others who could answer. One curiosity was the response from four social scientists in the United States. They all wrote to explain that since their field was social impact assessment, they could not supply answers about environmental impact assessment. This seems contrary to the thrust of NEPA, which seeks a balanced approach to EIA, with social impact assessment as part of the whole.

Comments about EIA

Several respondents from the third world wrote to explain the effect of EIA costs upon very poor countries. They stated that, even though this cost was only a small percentage of the overall project budget, it could be a critical one. They claimed that in some cases this increased cost represented the "make or break" of a project.

Related to the question of cost was that of expertise in the developing countries. Many respondents acknowledged that they did not have sufficient trained personnel. Further, they could not afford to train and maintain a battery of environmental technologists at the present time. One technologist strongly objected to filling of the review role by the staff of lending agencies. However, the answer may be the creation of regional "technology banks", perhaps under the aegis of the United Nations Environment Program or some other regional group.

Two respondents stated that data is lacking at the present time. Both emphasized the need to start gathering and sorting environmental data in their countries. Again, though, the question of cost arises. Perhaps the most cost-effective approach would be data-gathering on a regional basis, sharing efforts and avoiding duplication.

A comment which was commonly made is that the support structure for EIA is absent in most developing areas. First of all, there is a lack of awareness of the need for EIA among the political leaders. Next, the proportion of third world countries having EIA laws is smaller than the proportion of industrialized countries having such laws. Even where laws exist in the developing nations, they are not always complemented by environmental quality standards. In addition, the enforcement of both laws and standards is a problem. Finally, technologists are subjected to a host of political and social pressures. These range from hints from supervisors to outright job threats and bribery attempts. The objective of this pressure is to bias study findings in favor of one or another alternative.

Some of the comments from industrialized areas are equally applicable in developing nations. From Canada came a plea for consistent and even-handed management of policy. Without this, industries tend to play off one local government body against another. The "prize" of increased employment and tax money goes to the area offering the best deal.

Another aspect of fairness in policy and law enforcement was highlighted by several respondents from the United States. This has to do with the objectives of EIA. When standards are excessively stringent, when review is unduly lengthy, or when enforcement is biased, the environmental efforts are seen as anti-development. As a result, industries seek to relocate and the local economy suffers.

Three respondents from Europe were of the opinion that the timing of assessments relative to project design is of critical importance. This opinion was shared by a consultant from Canada (Nancarrow, 1979). Reactive assessments are those done after project design has been completed. These, at best, delay project implementation. At worst, they call for expensive redesign, or abandoning of the project after much money has been spent. The ideal assessment is one which is integrated into project design. One representative of a large industry in England pointed out that such integration can be and has been done successfully.

Comments about the Questionnaire

In a previous section of this chapter, it was reported that some respondents found the environmental parameters to be too general to rate reliably. This same comment was made about the criteria in Part IV of the questionnaire. One respondent from Africa went further. His comment was that the criteria were biased towards a capitalist system and the Western social structure. He questioned the relevance of these criteria in a different social and political setting.

Two persons from Canada objected strongly to the whole survey. They cautioned against the imposition of Western social values upon the third world. They also questioned whether a multiple-choice questionnaire would generate any meaningful data. Because of the strongly negative tone of both these letters, one was followed-up by phone and the other by letter. In the phone conversation, the first person explained that he did support the idea of examining the environmental consequences of projects. However, he felt that project decisions should be made purely by the affected population, without the influence of lending agencies or foreign (or foreign-trained) experts. No reply was received from the second person.

On the other side of the coin, several persons from developing countries felt that research into EIA in developing countries was a useful exercise. This comment was made by persons who completed the exercise as well as those who did not. This attitude reflects the general support for environmental assessments that was noted earlier in this chapter.

Conceptual Framework for EIA in Developing Countries

Based on the four flow-charts presented in Chapter II, two less formalized discussions of the EIA process (van Rest, 1981; and Munn, 1982), and the general comments received from respondents to the questionnaire, a conceptual framework for conducting EIA in developing countries was constructed. This is shown on Table VI.19. In each case, the timing of the activity is indicated, and the persons responsible for that step are listed. Nine steps are involved. These are Preliminary Activities; Impact Identification; Baseline Studies; Impact Evaluation; Mitigation Measures; Assessment and Comparison of Alternatives; Documentation; Decision-Making and Post Audit. A discussion of each of these steps follows:

1) Preliminary Activities include all that must be done before the environmental study itself can be started. Included are a description of the development being considered; preliminary design of the alternatives for achieving the development; selection of the assessment team; review of applicable laws, regulations and ordinances; and identification of the competent decision-makers. These activities are shared by the project managers and the environmental team which they select. The work should be done during and shortly after the engineering feasibility study.

2) Impact Identification is the scoping of the environmental study. Based on previous projects of the same type and what is known of the project area, possible impacts are listed. This allows the development of a systematic plan for the rest of the environmental study. This step should be undertaken as soon as possible after the feasibility study is accepted and the project approved. Impact identification is the responsibility of the environmental team.

3) Baseline Studies are conducted to establish the status quo in the area that will be affected by the development. The results of these studies include descriptions of the physical-chemical, biological, cultural and socio-economic environments; prevalent trends of changes in these environments; and a survey of social and cultural values in the affected area. Cost efficiency would be achieved if the environmental baseline studies are conducted simultaneously with the preliminary engineering design activities. Where field studies are necessary, it may be possible to have engineering and environmental work done by

Table VI.19: A Conceptual Framework for EIA in Developing Countries

Assessment Step	When?	By Whom?
1. Preliminary Activities	During Feasibility Study.	Project Management and Environmental Team.
2. Impact Identification (Scoping)	Between Feasibility Study and Preliminary Design.	Environmental Team.
3. Baseline Study	During Preliminary Design.	Environmental and Engineering Teams.
4. Impact Evaluation	Between Preliminary and Final Design.	Environmental Team and Technical Specialists.
5. Mitigation Measures	Between Preliminary and Final Design.	Environmental Team with input from Engineering Team.
6. Comparison of Alternatives	Before Final Design.	Environmental Team.
7. Documentation	Before Final Design.	Environmental Team.
8. Decision-making	Before Final Design.	Project Management.
9. Post Audits	After the Start of Operation.	Project O & M.

the same personnel. The baseline study should be shared by the engineering and environmental teams. At this stage, too, input must be sought from the specialists who will use the data gathered to make predictions.

4) Impact Evaluation refers to the technical tasks of calculating impact magnitude, and evaluating their significance. This must be done for each project alternative, including the no-action alternative. Both beneficial and adverse impacts should be studied. Impact evaluation is done by the environmental team, assisted by technical specialists as necessary. This work must be done before alternatives can be compared and a decision made on which one will be implemented.

5) Mitigation Measures must be planned to reduce adverse project impacts. Since not all adverse impacts can be mitigated against, the first part of this step involves identification of those effects which can be ameliorated. Thsoe which cannot must be red-flagged. Where adverse effects can be reduced, the cost and other implications of mitigation must be studied. The identification of available measures must also precede the comparison of alternatives. This work is the responsibility of the environmental team, but strong input from the engineering team is advisable.

6) Assessment and Comparison of Alternative is based upon the results of the baseline study, the predicted impacts, and the mitigation measures proposed for each alternative. The technique used in selection of the preferred alternative should be weighted to reflect the local cultural and social values identified in step 3. Traditionally, this step has been seen as the decision-making phase. In developing countries this is not a realistic view. In most cases, the environmental team will not be given the authority to choose the project alternative to be implemented. Instead, their findings will be presented as recommendations to the project managers, be they industry or government.

7) Documentation of the study and recommendations is very important, particularly where the final decisions are not made by those conducting the study. Where the EIA is required by law, the format and content of the report is often spelled out in the legislation. At the very minimum, the document prepared by the environmental team should contain a project description, a description of the affected environment, a discussion of the methodologies used, a statement of findings which details impact predictions and evaluations, and a clear statement of recommendations.

8) <u>Decision-Making</u> should be based upon the findings and recommendations in the report prepared in step 7. In many countries, and particularly in developing countries, the final decision on the project or program alternative to be implemented is not made by the assessment team. Instead, the choice is made by a government or management body acting on the advice of the assessment team. It is therefore imperative that recommendations be unambiguous, and that reasons for these recommendations be effectively communicated. Since governments and management are (or should be) accountable to the populace and shareholders, respectively, the environmental report should be both understandable and defensible.

9) <u>Post Audits</u> are continued monitoring activities after project implementation. They are conducted to determine the accuracy of the environmental study, with a view to improving future studies. Thus, they may be considered a part of research and development. Post audits have not been a common practice to date, but there is a growing recognition of their potential usefulness. On most large projects, there is a regular program of inspection and maintenance. It may be possible to include simple environmental monitoring as part of this program, to be done by the project operators. More technically complex monitoring can be done during periodic visits by a specialist.

CHAPTER VII

ASSESSMENT METHODS

In Chapter IV, various methodologies available for use in performing the various steps of an EIA were introduced. The applicability of each methodology to particular steps in an assessment were summarized, and various desirable attributes of methodologies were presented. In this chapter and Chapter VIII, specific methods and techniques which may be useful in developing countries will be presented. For convenience, these assessment tools have been divided into two broad categories: assessment methods and prediction techniques. Assessment methods are those used to identify impacts, describe the affected environment, and compare alternatives. These are the methods which were developed after the enactment of NEPA specifically for use in environmental studies. Many methods are available for impact identification and comparison of alternatives. Several of these are also useful in describing the affected environment. However, there are very few methods which are available exclusively for use in the baseline study. Assessment methods are reviewed in this chapter.

The prediction techniques are those tools which are used to quantify the level of changes in the environment which will result from implementation of a project. They differ from assessment methods in two ways. First, these techniques involve many fields of the physical, biological and social sciences. Secondly, many of these methods and models predate the environmental era. The review of prediction techniques in Chapter VIII is, of necessity, a limited one. The intent is to introduce the more common techniques and to illustrate the many and diverse environmental parameters for which prediction techniques are available.

Impact Identification

Impact identification is the task of determining which aspects of the environment will be affected by the alternatives to a project. This is done by considering the actual effects of previous projects, by drawing upon the experience of technologists who are familiar with the project and its setting, and by the use of systematic methods. The methodologies which are used most often to identify impacts are matrices and checklists. Networks have also been used for impact identification. The following are summaries of some methods used to identify impacts.

UNEP Checklist for Siting of Industry

An extensive checklist has been assembled by the UNEP to aid in the siting of industries (UNEP, 1981). In this method, the environment is divided into ten elements, and each element further broken down into sub-elements. The ten elements and number of sub-elements in each are as follows:

Climate and air quality (4)
Geology (6)
Ecology (5)
Land use and land capability (2)
Visual quality (1)
Water (7)
Soils (7)
Environmentally sensitive areas (4)
Noise and vibration (3)
Archaeology, historic and cultural (2)

A screening table has been developed for each element of the environment. These tables list sub-elements, potential impacts, required information and sources of information. The potential impacts column contains a series of questions designed to indicate the most important potential problems associated with each sub-element. The required information column lists the types of data required to predict the magnitude and importance of changes to each sub-element. The sources of information column identifies sources from which required information may be sought.

Table VII.1 is a composite assembled from four different screening tables. The task of impact identification for each project alternative will consist of answering the "potential impact" questions for each sub-element on the checklist. These answers will provide a list of sub-elements which will probably be affected by that alternative. This list then forms the basis for the baseline study, the quantitative prediction of impact magnitude and importance, and mitigation planning.

USAID Checklist for Rural Development Projects

The United States' Agency for International Development (USAID) has designed a system for assessing the environmental impacts of rural

Table VII.1: Composite Screening Test Table for UNEP Checklist for Siting of Industry (UNEP,1981)

Element	Subelement	Potential Impact(s)	Required Information	Sources of Information
Climate and Air Quality	Wind: directions and speed	Will the project (structure and area) modify the local wind behavior, e.g. channelling of wind, obstruction, etc? Will the project be placed in a "high risk" area?	Wind speeds and directions, including unusual conditions - tornadoes, etc. Height of structures.	Meteorological records; existing residents in area. Developer.
Ecology	Biogeochemical/ nutrient cycling	Will project activities disrupt nutrient materials flow, e.g. selective concentration/dilution of substances?	Extent of project; Disturbance of natural communities; soils type and erodability; slope and topography; drainage patterns; annual precipitation.	Developer Soils surveyor/ ecologist/ hydrologist
Geology	Mineral resources	Are there mineral resources of potential value close to the project?	Location of mineral sources and current economic significance; presence of mine, quarry or other extractive activity.	Geological maps/ survey. Mining records; mineral resource map.
Archeology, historic and cultural	Historic/ cultural structures, sites and areas	Will the project conflict with structures, sites and areas of historic/cultural interest and value? Will existing and desirable future patterns of access be disrupted?	Location of project knowledge of regional and local historic/ cultural sites and areas; patterns of visiting and use by elements within the surrounding population	Developer Regional/local historical socieites. Social and economic statistics on mobility, associational and recreational patterns

development projects in developing nations (USAID, 1980). In this system, impact identification is facilitated by a descriptive checklist, and the results displayed as a matrix.

The first step in this system is the completion of a Project Planning Checklist, which consists of 31 environmental components. These are listed in Table VII.2. Of the components listed, nine come from the physical-chemical environment, nine from the biological, eight from the socio-economic, and five from the cultural environment. For each component, a series of questions is posed. A typical set of questions appears in Table VII.2. Potential adverse and beneficial effects are identified as the questions are answered. Where the answers are "unknown", this indicates that more in-depth study is needed. The list of potential impacts that results from the application of this checklist is the basis of the description of the affected environment, the prediction of impacts, and mitigation planning.

Schaenman's Checklist for Land Development Projects

Schaenman (1976) devised a descriptive checklist which can be used to identify the impacts resulting from housing and other land development. It contains a total of 47 factors summarized in Table VII.3. Corresponding to each factor are "bases of estimate": a brief, simple listing of key data and models (if any) needed to further evaluate the factor. Examples of these bases of estimate are as follows:

Table VII.2: The USAID Checklist for Rural Development Projects (USAID, 1980)

a. Environmental Components Considered

Agricultural Lands	Soil Erosion	Slope Stability
Energy/Mineral Resources	Surface Water Quality	Surface Water Quantity
Ground Water Quality	Ground Water Quality	Air Quality
Noise	Aquatic Ecosystems	Wetland Ecosystems
Terrestrial Ecosystems	Endangered Species	Migratory Species
Beneficial Plants	Beneficial Animals	Pest Plants
Pest Animals	Disease Vectors	Public Health
Resource/Land Use	Energy Sources	Distribution Systems
Employment	At-Risk Population	Migrant Populations
Community Stability	Cultural/Religious	Tourism/Recreation
Nutrition		

b. Typical Questions for an Environmental Component

Component: Agricultural Lands

a)	Are there cultivable lands in the project area?	Yes/No/Unknown
b)	Will project decision result in more or improved cultivable lands?	Yes/No/Unknown
c)	Will project decision result in less or damaged cultivable lands?	Yes/No/Unknown

Table VII.3: Schaenman's Checklist For Land Development Projects (Schaenman, 1976)

A) <u>Land Economy</u>:	
(1) Public Fiscal Balance	(2) Employment
(3) Changes in Land Values	
B) <u>Natural Environment</u>:	
(4) Air Quality/Health	(5) Air Quality/Nuisance
(6) Water Quality	(7) Noise
(8) Wildlife and Vegetation	(9) Threatened and Endangered Species
(10) Natural Disasters	
C) <u>Aesthetics and Cultural Values</u>:	
(12) View Opportunities	(13) Landmarks
D) <u>Public and Private Services</u>	
(14) Water Availability	(15) Water Quality
(16) Hospital Emergency Care	(17) Hospital Crowdedness
(18) Crime Rate	(19) Security
(20) Fire Protection	(21) Public Recreation Opportunities
(22) Public Recreation Crowdedness	(23) Public Recreation Accessibility
(24) Informal Recreation Opportunities	(25) Informal Recreation Accessibility
(26) Quality of Schools	(27) Travel Time to Schools
(28) Reassignment of Students	(29) School Crowdedness
(30) Quality of Mass Transit	(31) Accessibility of Mass Transit
(32) Pedestrian Facilities	(33) Traffic Safety
(34) Traffic Accidents	(35) Travel Time
(36) Parking Availability	(37) Parking Distribution
(38) Quality of Shopping Areas	(39) Crowdedness of Shopping Areas
(40) Energy Services	(41) Housing Quality
(42) Housing Availability	(43) People Displacement
E) <u>Other Social Impacts</u>	
(44) Special Hazards	(45) Sociability/Friendliness
(46) Privacy	(47) Contentment with Neighborhood

Housing Availability - "Current profile of housing units added or destroyed; past housing chain effects in distribution of population by income level; indicators of latest demand for housing."

Air Quality/Health - "Current ambient concentrations, current and expected emissions, dispersion models, population maps."

When impacts have been identified using the factors on the checklist, the "bases of estimates" give guidance for the on-going activities of baseline studies, impact prediction and mitigation planning. This checklist places far greater emphasis on socio-economic and cultural planning than either of those discussed previously. Forty of the factors listed relate to effects on man, society and the quality of life. Only seven relate tc the physical-chemical or biological environment. Considering the type of project for which this checklist was designed, the emphasis on socio-economic and cultural impacts is understandable. By their very nature, land development projects can be expected to have a major affect on man, society and the quality of life.

Hittman Associates' Checklist for Construction Activities

Hittman Associates (1974) developed a checklist of potential impacts related to the construction of nuclear power plants and associated facilities. The items in this checklist are typical of those which would result from any major construction. The Hittman list is divided into four construction phases: preconstruction, site work, erection of permanent facilities, and project closeout. The preconstruction phase involves a site inventory, environmental monitoring and the establishment of temporary controls against flooding, erosion and dust.

The phase entitled "site work" involves preparation of the site for the erection of buildings. This phase includes five major areas of activity. Clearing and demolition involves the removal of vegetation and any condemned buildings. Temporary facilities include workshops and storage sheds, access roads and parking, installing temporary utilities, and pest control. Earthworks involve excavation, trenching and backfill, and site grading. Site drainage may include foundation drains, well points, surface drains and stream channel relocation. Finally, landscaping will necessitate both temporary and permanent plantings.

The erection of permanent facilities is usually the phase which results in the greatest construction impacts. Typically, the labor force, traffic on site and equipment spread are all at their peak during this phase. The facilities to be installed include buildings, roads, specialized structures, fencing, process equipment, and others as appropriate to the project.

Project closeout involves the removal of temporary facilities and the cleanup and restoration of the site. The Hittman checklist includes all of the activities included in these four phases. For each activity, the checklist notes potential impacts, and whether these will be short- or long-term. Table VII.4 lists the number of activities in each phase, and gives a few examples of the way potential impacts are listed.

Table VII.4: Hittman's Checklist for Construction Activities (Hittman Associates, 1974)

a) Distribution of Activities

Construction Phase	No. of Activities
Preconstruction	7
Site Work	20
Erection of Permanent Facilities	18
Project Closeout	2

b) Composite Example from Checklist:

Construction phase	Construction practice	Potential environmental impacts
Preconstruction	Site inventory	Short term and nominal
	Vehicular traffic	Dust, sediment, and tree injury
	Test pits	Tree root injury, sediment
Site work	Earthwork Excavation Grading Trenching Soil treatment	Long term Stripping, soil stockpiling, and site grading; increased erosion, sedimentation, and runoff, soil compaction; increased soil levels of potentially hazardous materials; side effects on living plants and animals, and the incorporation of decomposition products into food chains; water quality
Permanent facitilies	Security fencing	Long term
	Access road	Increased runoff
	Fencing	Barriers to animal movements
Project closeout	Removal of temporary offices and shops	Short term
	Demolition	Noise, solid waste, dust
	Relocation	Storm water, runoff, traffic blockages, soil compaction

Other Checklists

The four methods described previously are illustrative of checklist methods which have been used to identify environmental impacts. The list of checklists that have been used in environmental studies is extensive. In the early years following the passage of NEPA, many checklists were developed for a wide variety of projects (Canter, 1982). Examples include a simple checklist for gas pipeline projects (U.S. Federal Power Commission, 1973), and descriptive checklists for coastal area projects (Carstea, et al., 1976), water resources projects (Canter and Hill, 1979, Environmental Impact Center, 1973), dredging (Battelle-Columbus Laboratories, 1974), and transportation projects (U.S. Department of Transportation, 1975).

Other methods can be used to develop simple checklists for impact identification. Scaling, ranking, weighting-scaling and weighting-ranking checklists are all used to compare alternatives. As a preliminary exercise, however, they can all be used in impact identification. The list of factors to be scaled, ranked and/or weighted is a simple checklist. Similarly, the list of environmental parameters on several matrices can be used as a simple checklist for impact identification. Finally, a project specific checklist can be developed by reviewing environmental impact studies and post-audits on similar projects which have been implemented.

Clark's Matrix for Construction Activities

Matrices differ from checklists in that they illustrate cause and effect relationships. Clark's (1975) matrix was developed as part of a study of the environmental effects of construction activities. This matrix lists 75 construction activities under 12 headings on the vertical axis, and 50 environmental attributes under 11 headings on the horizontal axis. These headings are listed in Table VII.5. When using the matrix for impact identification, each activity/attribute pair is considered in turn. Where an activity is expected to affect an attribute, an "X" is marked in the appropriate node. The matrix format allows a very large number of pairs to be considered systematically. This reduces the time taken for the exercise, and reduces the possibility of a pair being accidentally ignored. In a test of the matrix, Clark identified 700 possible impacts. This number is project specific.

The impacts identified in this matrix are unquantified. However, they can be considered as a simple checklist of activity/attribute pairs. This checklist can be used to plan the baseline study. It will also indicate the impacts which must be quantified using prediction techniques, and the areas where mitigation planning is required.

NEERI Matrix for Industrial Development

The National Environmental Engineering Research Institute (NEERI) of India has developed a simplified matrix for identifying likely impacts of industrial development (Raman, Bowonder and Sundaresan, 1980). This matrix is a simple one that includes only a few pertinent actions and effects. A matrix such as this will not be adequate to identify all the impacts of a large project. However, it

Table VII.5: Construction Activities and Environmental Attributes from Clark's Matrix (Clark, 1975)

Construction Activities:

1. Site Access
2. Preliminary Works
3. Utilities
4. Site Preparation
5. Demolition
6. Removal and Disposal
7. Earthworks, Excavation, Quarrying and Borrow
8. Tunneling and Subusrface Excavation
9. Foundations
10. Bituminous, Concrete, Masonry, Wood and Steel Construction
11. Finishing
12. Landscaping

Environmental Attributes:

1. Air Quality
2. Surface Water
3. Ground Water
4. Earth Sciences
5. Ecology
6. Health Sciences
7. Noise and Vibration
8. Regional Economy
9. Transportation
10. Land Use
11. Socio-Cultural

can certainly be useful in identifying impacts of isolated parts of the program. The use of simple matrices such as this one can assist in identifying localized impacts which may be missed by an overall project matrix or checklist review.

The NEERI matrix for identifying the impacts of industrial development lists 28 major environmental parameters in 9 groups on the horizontal axis, and 15 causative factors on the vertical axis. These parameters and factors are listed in Table VII.6. As before, impact identification is done by systematically considering parameter/factor pairs in order, and marking those where the causative factor is expected to affect the parameter. The output of the exercise will be a list of anticipated impacts from each project alternative. This can then be used as a checklist of parameters to be high-lighted in the baseline study, and of impacts to be quantified and mitigated against.

Leopold Interaction Matrix

Perhaps the best-known of all matrix techniques for impact assessment was published by Leopold and others in 1971. The matrix consists of 98 actions across the top and 86 environmental items on the vertical axis. The actions are grouped into 11 categories, and the environmental items into 5 categories. Table VII.7 is a summary of these categories, the number of items in each category, and examples of the items.

Despite the size of the matrix as originally designed, this method can be enlarged or reduced as needed to suit a particular project. This is done by reviewing the lists of actions and items

Table VII.6: Parameters and Causative Factors from the NEERI Matrix (Raman, Bowonder, and Sundaresan, 1980)

Group and Parameters:

1. Environmental Pollution - air, water, solid waste, noise and vibration.
2. Human Habitat - health and safety, economics, social and cultural, displacement, employment, housing, occupational, human reactions, transport, other.
3. Ecology and Conservation - flora and fauna, landscape, recreation, archeology.
4. Aesthetics - land, water, air
5. Utilities - water supply, energy, etc.
6. Site conditions - foundations, etc.
7. Work Environment
8. Cost and Economic Importance - benefit/cost, risk/benefit, recycling.
9. Political considerations.

Causative Factors:

1. Liquid waste generation
2. Solid waste generation
3. Air pollutant emissions
4. Noise and vibration generation
5. Odor and color producing agents
6. Displacement of human habit
7. Constructional activities
8. Operational activities
9. Movement of people
10. Displacement of existing economic activities (e.g., agriculture, fishing, small scale industry, etc.)
11. Transportation
12. Accidents and hazards (within and outside work environment)
13. Earthwork and landscape modification, site clearance
14. Cost factor
15. Utilities - water resources, energy consumption, etc.

Table VII.7: . Summary of Items in the Leopold Matrix (Leopold, et al., 1971)

Category	# of Items	Examples
A) <u>ACTIONS</u>		
1. Modification of Regime	13	Biological Controls, Burning
2. Land Transformation and Construction	19	Urbanization, Airports, Canals
3. Resource Extraction	7	Drilling, Forestry
4. Processing	15	Farming, Oil Refining
5. Land Alteration	6	Erosion control, Landfilling
6. Resource Renewal	5	Reforestation, Recyling
7. Changes in Traffic	11	Trucking, Pipelines
8. Waste Replacement and Treatment	14	Sanitary landfills, Ocean dumping
9. Chemical Treatment	5	Fertilization, Soil Stabilization
10. Accidents	3	Explosions, Spills and leaks
11. Other Actions	As required	
	98	
B) <u>ENVIRONMENTAL ITEMS</u>		
1. Physical and Chemical Characteristics	25	Land form, Water recharge, Climate slope stability
2. Biological Conditions	18	Flora, Fauna
3. Cultural Factors	36	Land use, Recreation
4. Ecological Relationships	7	Eutrophication, Food Chains
5. Other Items	As required	
	86	

prior to use of the matrix. Those actions which are not included in any of the project alternatives, and those items not relevant to the sites under consideration are deleted. On the other hand, any actions or items present in the project or site but absent from the matrix are added. The impact identification process of considering each action/item pair is then conducted. As with other matrices, the results will be a checklist of potential impacts. This list assists in planning the baseline study, and the impacts on the list must be quantified before alternatives can be compared or mitigation planned. The use of the Leopold matrix to compare alternatives will be discussed in a later section.

Other Matrices

The three methods just described are representative of the various sizes of matrix methods which can be used to identify impacts. The basic advantages of matrices over checklists for this step of the assessment are twofold. First, the interaction matrix shows the interrelationship between project actions and environmental changes. This is particularly useful when planning mitigation measures, since adverse effects are clearly linked to causative actions. The second advantage is that the matrix format facilitates the consideration of a large number of impacts by reducing the chance of inadvertently ignoring effects of particular project actions on specific environmental parameters.

Several matrices have been developed for specific project types. Some are modifications of the basic Leopold Matrix. The

Federal Aviation Administration (FAA) has used matrices on aviation projects (FAA, 1973). The Oregon Highway Department has devised a matrix for highway projects (Canter, 1977). Matrices have also been used on a coal mine development and on several infrastructure projects (Chase, 1973).

Sorenson's Network Notation

Networks can be used to clearly identify secondary and tertiary effects of a project. These are not always apparent from checklists or matrices. Sorenson (1971) used a network diagram to illustrate the impacts and interrelationships associated with a dredging project. Using his notation, a highly simplified network for a channel realignment project was drawn (see Figure VII.1).

The problem faced was one of flooding in areas adjacent to a meandering river. The project proposed was realignment of the channel. This was to be achieved by cutting a new, straighter and steeper channel and filling in the old one. The immediate effects of these actions were the exposure of virgin soil in the new channel, an increase in the channel gradient, and the destruction of ground cover during construction. Because the channel gradient was steepened, flow velocities increased. These increased velocities, coupled with the presence of virgin soil, increased the scouring of the channel walls. On the banks of the river, the absence of vegetation increased the rate of erosion by runoff. The increased velocities had the desired results of reducing flooding. A second, adverse effect was a turbidity problem which resulted from the scoured and eroded material entering the water.

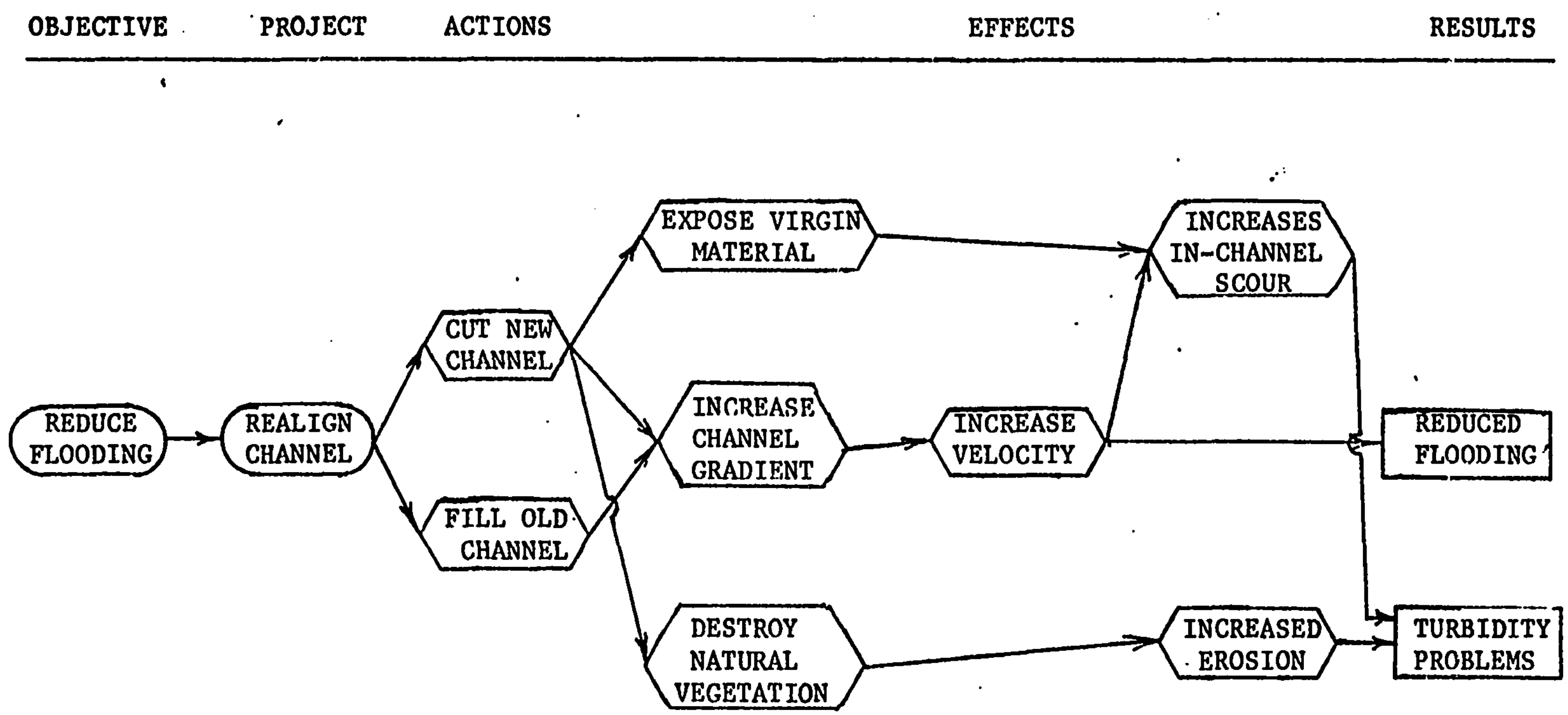


Figure VII.1: Simplified Network for Channel Realignment (Sorensen's Notation)

In as simple a problem as the one just described, the use of a network may seem trivial. However, in complex projects they can be invaluable in establishing interrelationships and higher-order impacts. They can be particularly useful in identifying impacts on the biological and social environments. In the former case, food chain networks can be used to study effects of project alternatives. In the latter, such intangibles as leadership and social influence can be mapped using networks. Once impacts have been identified by a network, baseline studies can be initiated and changes quantitatively assessed. Because networks clearly delineate cause and effect, they are particularly useful in planning mitigation of impacts which have been identified.

U.S. Soil Conservation Service Network Notation

The U.S. Soil Conservation Service (SCS) (1977) has developed a different network notation from that used by Sorensen. Using this second notation; a simplified network for a housing development is shown in Figure VII.2. It should be noted that Figures VII.1 and VII.2 are presented for discussion and illustration only. Networks for actual projects will be far more complex than these, even when the projects are relatively minor ones.

The SCS notation groups items under eight headings. The first column describes the specific alternative being represented in the network. The second group lists the basic resources which will be impacted. The next four columns address effects in each of four areas of the environment: changes in land use and cover, physical and

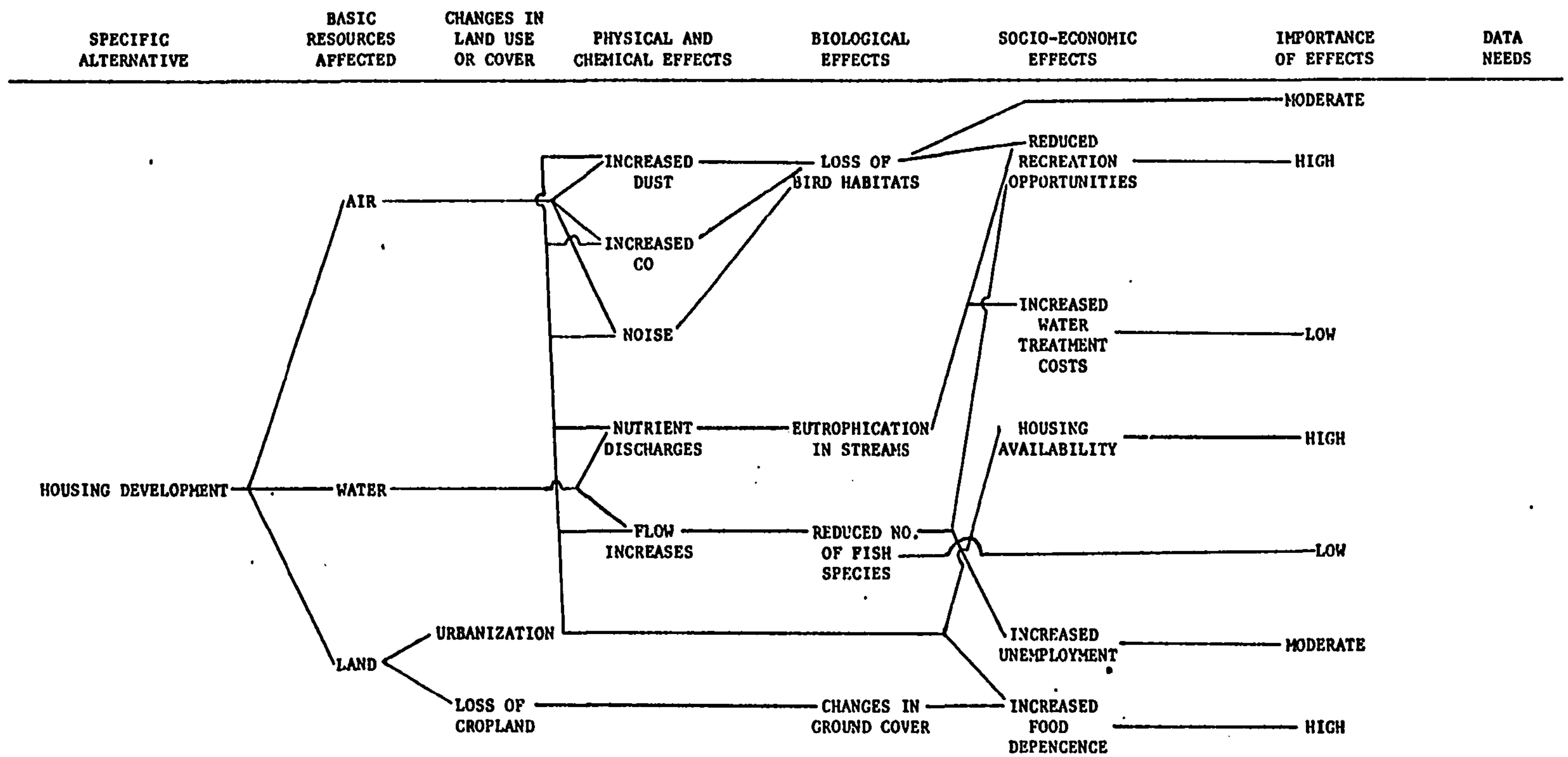


Figure VII.2: Simplified Network for Housing Development (U.S. Soil Conservation Service Notation) chemical effects, biological effects, and socio-economic effects. Lines are drawn to show interrelationships. For example, urbanization leads to air pollution in the form of dust and carbon monoxide, the latter from automobile exhausts. It also affects the water and land environments. The air pollutants, coupled with noise, make the area unsuitable for the nesting of birds. This loss of birdlife, in conjunction with eutrophication in streams and reduction in the number of fish species makes the area less attractive for recreation.

The penultimate column rates the importance of the effects listed in the middle four columns. In this case, reduced recreation opportunities, housing availability and increased food dependance are rated as highly important. Loss of bird habitats and increased unemployment are considered moderately important. Increased water treatment costs and the reduced number of fish species are relatively unimportant in the example.

The final column lists the type of data that will be needed to quantify the important impacts which have been identified in the network. The benefits of this network are the same as discussed for Sorenson's notation: second- and higher-order impacts can be identified; baseline studies can be planned; identified impacts can be studied further and quantified; and mitigation measures can be planned.

Evaluation of Methods

Three of the criteria included in Part 4 of the questionnaire related to methods of impact identification. These were comprehensiveness, data and expertise. The first required that the method address all aspects of the environment, and interrelationships between these parameters. The second emphasized the use of data which is available, or easy to obtain. The third criterion concerned the method's use by local technologists.

The importance rating of each of these criteria is analyzed in Appendix B. For comprehensiveness and expertise, there were no significant differences based upon level of development, geographical region, employment, education or specialized environmental training. The only significant differences among the ratings of the data criterion was with respect to geographical region. The United States and Canada rated this criterion somewhat less important than other regional groups. More will be said of this difference in the section on baseline studies.

There were no significant differences in criteria ratings within the third world. It was therefore decided to pool all responses from developing countries and evaluate impact identification methods on that basis. The evaluation of methods (based on a scaling-weighting exercise) is shown in Table VII.8. In the second line of the table, it will be noted that comprehensiveness and data are rated as very important, while the other criterion is rated between average and very important. The total score for each method is the sum of the products of the criteria importance weights and the compliance scores.

Each compliance score is a measure of the degree to which the method satisfies the appropriate criterion. The scores are on a scale of 0 to 4, as shown on Table VII.8. For comprehensiveness, networks received the highest scores, because they directly address

Table VII.8: Evaluation of Impact Identification Methods

Criteria:	Comprehen-siveness	Data	Expertise	Total	
Criteria Importance Weight (IW):	4.03	4.00	3.57	Score= $\Sigma IW.CS$	Rank
Method	Compliance Scores* (CS)				
UNEP Checklist	2	4	3	34.77	1.5
USAID Checklist	2	4	3	34.77	1.5
Schaenman's Checklist	1	2	3	22.74	7
Hittman Associate's Checklist	1	3	3	26.74	6
Clark's Matrix	2	3	3	30.77	4
NEERI Matrix	1	4	3	30.74	5
Leopold Matrix	3	2	3	30.80	3
Sorenson's Network Notation	3	1	1	19.66	8.5
US Soil Cons. Ser. Network Notation	3	1	1	19.66	8.5

*Criteria Compliance Scores: 0 = non-compliance,

1 = marginal compliance, 2 = moderate compliance

3 = good compliance, 4 = excellent compliance.

interrelationships. Some of the checklists and matrices got the lowest scores, because they do not address the whole range of parameters. Checklists and matrices received higher data scores, while networks received lower ones. This is because networks tend to require more specialized data about causes and effects. Checklists and matrices are fairly simple to use, while networks require more expertise. Hence the differences in compliance scores.

A total score was computed for each impact identification method. Higher scores indicate more appropriate methods for the third world. Based on these, the methods were ranked. The UNEP and USAID checklists were jointly most appropriate. Next in order come the three matrices, then the other two checklists, and finally the two networks. It is noteworthy that the two methods that were specifically developed for use in developing areas ranked the highest.

Summary

This section has dealt with methods for identifying the potential impacts of a project. Capsulized descriptions of nine methods were presented: four checklists, three matrices and two networks. These methods are representative of the types that can be used in this step of an environmental study. These nine methods were ranked in order of appropriateness for use in the third world. The ranking procedure employed the scaling-weighting technique, using the criteria importance weights from the international questionnaire. Checklists and matrices were the most appropriate, and networks the least.

Table VII.9 contains a summary of 29 methods (with references) which can be used for impact identification. It is divided by methodology, and includes the 9 methods discussed in this section. The next section deals with methods of describing the affected environment. To be effective, the baseline study should high-light those areas in which potential impacts have been identified. Thus, the description of the affected environment is closely related to the impact identification exercise.

Baseline Study

Relatively early in the environmental assessment exercise, a baseline survey should be conducted. The objective of this step is to establish the status quo in the project area. The written output is a description of the affected environment. The results of the study will be used in the prediction (quantification) of impacts, and also in the comparison of project alternatives. To be effective, the study should focus on those environmental parameters which would be affected by the project. Thus, a good time for conducting the baseline study is concurrent with or immediately after the impact identification step.

Canter (1977) identified four reasons for preparing a description of the affected area. These are:

(1) To provide a basis for assessing impacts,

(2) To familiarize decision-makers and reviewers with environmental characteristics of the project area,

(3) To relate the need for the project to the selected sites, and

(4) To identify environmentally significant items prior to project implementation.

Table VII.9: Summary of Methods for Impact Identification

Project Type	Reference
A) CHECKLISTS	
*Siting of Industry	United Nations Environment Program, 1981
*Rural Development	U.S. Agency for International Development, 1980
*Land Development	Schaenman, 1976
*Construction Activities	Hittman Associates, 1974
Gas Pipelines	U.S. Federal Power Commission, 1973
Coastal Area Development	Carstea, et al., 1976
Water Resources	Canter and Hill, 1979
Water Resources	Environmental Impact Center, 1973
Dredging	Battelle-Columbus Laboratories, 1974
Transportation	U.S. Department of Transportation, 1975
Dams and Reservoirs	Ortolano and Hill, 1972
Airports	Gillam and Canter, 1973
Water Resources	Dee, et al., 1972
Social Impacts of Highways	Adkins and Burke, 1974
Social Impacts of Waterways	Canter, Risser and Hill, 1974
Transportation	A. D. Little, Inc. 1971
Land Development	U.S. Soil Conservation Service, 1974
B) MATRICES	
*Construction Activities	Clark, 1975
*Industrial Development	Raman, Rowonder, and Sundaressan, 1980
*General	Leopold, et al., 1971
Aviation	Federal Aviation Administration, 1973
Highways	Oregon Highway Department, quoted by Canter, 1977
Coastal Zone Development	Moore, et al., 1973
General	Fischer and Davies, 1973
General	Kruzic, 1974
Wastewater Systems	Phillips and De Filippi, 1976
General Long-range Impacts	Schlesinger and Daetz, 1975
C) NETWORKS	
*Dredging	Sorenson, 1971
*Land Development	U.S. Soil Conservation Service, 1977

*indicates a method which was described in this section

One of the key decisions relating to the baseline study is its scope. The extremes are a cursory review of existing data and an attempt to gather all possible information into an exhaustive study. Too brief a survey, such as a cursory review of existing data, will not provide sufficient foundation to build a meaningful environmental study. On the other hand, an attempt to gather all possible information through field studies is self-defeating. The data-gathering exercise will continue indefinitely, consuming project planning resources, and never producing final results. What is required is a middle course where environmental factors which will be affected by the project are included, but those which are relatively unaffected are ignored. In this concept, the most attention is paid to those environmental factors which are expected to undergo the greatest changes. This process of "scoping" for a baseline survey, and for environmental studies in general, is very important if time, money and manpower constraints are to be met. Scoping is addressed in the 1979 CEQ regulations (Federal Register, 1978).

There are very few methods which have been developed exclusively for use in describing the affected environment. If the survey is based on the results of the impact identification exercise, the list of items affected by the project can be used as a checklist. The remainder of this section will be devoted to specific means of conducting and presenting the baseline survey. Three useful methods will be described: the Habitat Evaluation System, a chart for cataloging baseline data on habitat quantity and the UNEP checklist. The use of visual aids will be considered, and the importance of existing databases will be discussed. Finally, a method for allocating limited resources in a baseline study is presented.

The Habitat Evaluation System

This structured habitat approach was developed as a means of comparing the effects of project alternatives on the biological environment in the Lower Mississippi Valley (U.S. Army Corps of Engineers, 1980). The system defines 7 habitat types, and describes each in terms of several parameters. It then goes on to award a numerical score to the altered biological system under each project alternative. These scores are then used to compare impacts. The exact scoring procedure is described in the cited reference. What is important here is that the initial steps of dividing a given area into the 7 habitat types and measuring each of the parameters can be used as a means of describing the affected environment.

The habitat types defined in the system are freshwater streams, freshwater lakes, bottomland hardwood forests, upland hardwood forests, open (non-forested) lands, freshwater river swamps and freshwater non-river swamps. The number of parameters used to rate each habitat type, and examples of these parameters, are as follows:

- Freshwater streams: 8 parameters, including sinuosity, turbidity and diversity of fishes.
- Freshwater lakes: 10 parameters, including depth, channel type and standing crop of fishes.
- Bottomland hardwood forests: 15 parameters, including species association, ground cover diversity and flood frequency.
- Upland hardwood forests: 6 parameters, including quantity of edge and number of trees per acre.

- Freshwater river swamps: 6 parameters, including percent woody forest cover and percent of area flooded annually.
- Freshwater non-river swamps: 5 parameters, including percent of area covered by ground cover.
- Open (non-forested) lands: 4 parameters, including land use and land use diversity.

For each parameter of each habitat type, the system describes primary and secondary characteristics. Table VII.10 is a composite from the six tables actually included in the system. The primary characteristics are the actual data which will be presented in describing the affected environment. This data, together with importance weights and scaling functions can be used to derive a numerical score for the existing system as well as for the altered system under each project alternative. The Habitat Evaluation System can be used to organize the baseline study. This will be particularly useful if the system is used later to compare alternatives.

A Chart for Cataloging Baseline Data on Habitat Quantity

A matrix layout (Canter, 1981c) for presenting data on habitat quantity is shown on Figure VII.3. In this format, various habitat types are listed across the top of the matrix, and various species of birds, mammals, reptiles, amphibians and fish in the left-hand column. At the intersection of each species and habitat type, the quantity of that species in that habitat at the project site is noted. A dash (-) indicates that the species is not normally found in that habitat type. Otherwise, descriptors such as "abundant", "common", "scarce" and "absent" are used to indicate the existing (pre-project) situation.

Table VII.10: Examples of Parameters Used in the Habitat Evaluation System (U.S. Army Corps of Engineers, 1980)

PARAMETER	PRIMARY CHARACTERISTIC	SECONDARY CHARACTERISTIC
FRESHWATER STREAM:		
Sinuosity	Meander pattern	Habitat diversity, aeathetic value, flow characteristics
Dominant centrarchid	Dominant predatory fishes	Water quality history, sport fishing potential, aesthetic value, community structure
UPLAND HARDWOOD FOREST:		
Quantity of edge	Habitat diversity	Browse production, wildlife carrying capacity, esthetic values, wildlife diversity, recreation potential
Mean distance to edge	Habitat diversity	Browse production, wildlife carrying capacity, esthetic values, wildlife diversity, recreation potential
FRESHWATER NON-RIVER SWAMP:		
Groundcover diversity	Community structure	Year-round food and cover production, esthetics
Percent of area covered by groundcover	Browse production	Wildlife habitat carrying capacity, cover potential, erosion control
OPEN LANDS:		
Land use	Dominant cover	Wildlife food and cover potential, carrying capacity, esthetics
Diversity of land use	Crop pattern	Wildlife habitat diversity, esthetics

	HABITAT TYPES AT OR NEAR DEVELOPMENT SITE					
	DECIDUOUS FOREST	CONIFEROUS FOREST	OLD FIELD/ GRASSLANDS	WETLAND	STREAM	POND/LAKE
BIRDS						
Species 1	Abundant	-	-	-	-	-
Species 2	Common	Absent	-	-	-	-
:						
MAMMALS						
REPTILES						
AMPHIBIANS						
FISH						

Figure VII.3: Chart for Cataloging Baseline Data on Habitat Quantity

This chart is an effective way to summarize the results of field surveys of flora and fauna in the project area. The comments in each column give a general idea of the quality of that habitat type. For example, if all the expected species are scarce or absent from a particular habitat type, one may conclude that the type is of poor quality in the project area. Conversely, many ratings of "common" and "abundant" would be indicative of excellent quality. In addition, the absence of one or two expected species while others are "common" or "abundant" is a clue that a specific problem exists.

UNEP Baseline Summary Checklist

The UNEP has developed a descriptive checklist approach to describing the affected environment (UNEP, 1981). In this method, the environment is divided into 10 elements and 41 sub-elements. These are the same elements and sub-elements that were used in the UNEP Checklist for Siting of Industry, mentioned previously.

The descriptive checklist consists of ten tables, one for each element of the environment. For each sub-element, the appropriate table lists objectives, required information and specialists, methodology and findings or measurements. Table VII.11 is a composite from several of the tables in the checklist.

The objectives column lists the basic reasons why that sub-element should be included in the environmental study. Naturally, if the reasons for a particular sub-element do not apply to a specific project, that sub-element can be excluded from the study. The required information and specialists column indicates the type of data that will

Table VII.11: Composite Baseline Summary Table (UNEP, 1981).

Element	Subelement	Objectives	Required Information/ Specialists	Methodology	Findings Measurements
Environmentally Sensitive Areas	Prime agricultural land	Maintenance of food production crops and livestock.	Location of agricultural lands; land use classification; productivity levels. Agronomist	Location of site in relation to land capabilities.	Productivity levels of prime agricultural land.
Land Use and Land Capability	Land capability	Assess relationship of project construction and operation to land capability types.	Land capability classification. Agronomist/soil surveyor.	Locate proposed development in relation to land capability types.	Potential for adverse impact on land capability types.
Noise and Vibration	Internal Noise	To protect the hearing of employees and to ensure safe operation of the project.	Plant details and layout, structural details, noise levels produced by each item. Pattern of employment movement in working day. Noise expert.	Determine noise map within development/communication pattern, determine individual exposure.	Employee exposure to levels in excess of criterion in dB(A) Leg. Risk of hearing damage, risk of lack of communication.
Visual Quality	Visual content and coherence	Sense of time and place; sense of harmony.	Project plans; building design; pictorial images; visual observations. Landscape architect	Photographic analysis of intrusion; descriptive evaluation.	Defined scales of visual intrusion; judgement of coherence.

be required on any sub-element, and the kind and level of expertise that will be needed to study that sub-element. The methodology column suggests methods and techniques by which required data can be gathered. It should be noted that survey methods and expert opinion are included here. In the final column, the actual form of the data gathered is indicated.

The UNEP Baseline Summary checklist was developed for use in conjunction with the UNEP Checklist for Siting of Industry. Thus, the elements and sub-elements in these two methods are uniform, and the data gathered in the baseline summary checklist relates to the data used in the siting checklist. This general principle can easily be applied to other project types, since the checklists can be modified by adding or deleting elements and sub-elements as required. This concept of uniformity can be taken a step further, to the comparison of alternatives. After the level of impacts have been calculated, the list of elements and sub-elements can be used to form a scaling, ranking, weighting-scaling or weighting-ranking checklist. Alternatively, the list of elements and sub-elements can be placed on one axis of a matrix, and project actions on the other. As will be shown in a later section, there are numerical scaling methods that can be used to compare matrices for several project alternatives.

Evaluation of Methods

Of the nine criteria listed in the questionnaire, only comprehensiveness relates directly to methods of organizing the baseline study. Thus, the method which best satisfies this criterion may be considered most appropriate for use in the third world at the present time. Of the three methods described previously, only the UNEP checklist is intended to be comprehensive. Both of the others are designed for specialized applications.

Visual Aids

Perhaps the clearest statement of the effectiveness of visual aids is the old adage "a picture is worth a thousand words". In environmental studies generally, and specifically when presenting baseline data, the use of visual aids can be very effective in communicating concepts to the technologist as well as the lay reviewer. Among the visual aids which can be used in describing the affected environment are maps and overlays, graphs and bar charts, and photographs.

Maps and plans can be used to show the physical layout of items within a project area. In conjunction with transparent overlay sheets, they can be used to show the relationship between existing environmental elements. For example, the base map can be used to show physical elements like rivers, topography, coastline, etc. The first overlay can indicate biological elements, such as habitats, migration routes, etc. A second overlay can be drawn up to show socio-economic and cultural elements, such as land use, recreation areas, and urbanization. The final overlay would show the general area of the project, and tentative facilities layouts. Such a set of maps and overlays will clearly demonstrate the physical relationship of the project and the existing environment.

In many cases, the environmental items affected by a project are dynamic. In these cases, the effects are changes in trends rather than static situations. One good example is population. The impact of a project may not be a quantum jump in population level. Instead, it may be an increase in population growth. Thus, the baseline survey must report existing trends rather than static levels. Graphs and bar charts are excellent means of displaying trends. However, they should be carefully designed to ensure that they report trends accurately. For example, it would be misleading to present a graph of sewage production against time if in fact the volume of sewage produced is a function of population.

Photographs are a simple but very effective means of recording the existing conditions before project implementation. In the design phase, carefully sited photographs can be used as the base of photomontages to show how a particular vista will be changed by a project. During construction and operation baseline photographs can form part of a program of photographic records. At the Caroni-Arena Pumped Storage Complex in Trinidad, West Indies, photographs were used to track project progress and environmental changes. Prior to construction, photographs were taken of the site of each major project element. At regular intervals during construction, repeat photographs of each site were taken. The result was an instructive record of construction progress. This technique can also be used to trace environmental impacts.

Importance of Existing Databases

The use of existing databases can effectively reduce the cost and time requirements of the baseline survey. Some of the places where existing data can be sought are previous studies, local universities, professional societies and government agencies. Each of these sources has its own characteristics and successful data gathering will depend upon one of three things:

(1) Knowledge of what is available,

(2) Knowledge of bureacratic procedures, or

(3) Access to a "technological gatekeeper".

A technological gatekeeper is someone within the data-holding organization who knows what is available and how it can be obtained. In many cases, coordination with such a person is the only feasible way to get information.

In a discussion of "lessons learned" after 10 years of EIA in the U.S., Elmer Staats, former Comptroller General, stated that synthesis can sometimes be more useful than gathering extensive new data (Staats, 1982). Therefore, he recommended the study of previous EIAs when a new environmental study is being done. The benefits of this are twofold. First, the methods used in previous studies can be considered for possible use in the new study. Secondly, some of the actual baseline data in previous studies of near-by projects can be useful in the baseline study for the new project.

Universities are often an excellent source of local data, much of which has not been published. This is because of the on-going research at the undergraduate and graduate levels in these institutions. While it is true that the research activity at third world universities is less intense than in the industrialized countries, some investigation is done. In addition, the lecturers at these institutions often work as consultants to government or industry. Thus, it may be worth the time required to find out what data is available at local colleges and universities very early in the baseline survey.

The value of professional societies as a source of data lies in their membership. The rolls of such groups are an important list of "persons to contact" when the baseline study is being planned. Among the membership of these associations will be people with a wealth of detailed local information gained after years of experience. In addition to the actual data that such persons can provide, their input is also useful when the environmental report goes out for public review. The inclusion of details that can be provided by local surveyors, medical doctors and engineers will help to convince the public that the study has been thorough. Unfortunately, professional societies in many developing countries are somewhat dormant. However, where an active society exists, its importance should not be underestimated.

The final data source to be mentioned in this section is government agencies. Many agencies collect data in their specialized area as part of their day-to-day activities. In a few cases, the raw data is summarized in the periodic publications of these agencies. The problems which may be encountered are determining what exists, the form of the data (ranging from notes in files to computerized records), and measurement units. The scattering of data among several agencies has been discussed in Chapter III. The need to catalog and organize data was recognized by several respondents in Chapter VI. In addition, the problem of measurement units is particularly severe in those countries which are making the change from the British to the metric system. In spite of these problems, it is often less expensive to seek out and use existing data than generate it afresh.

Further insight into attitudes to data-gathering may be gained from the ratings of the data criterion in Part 4 of the questionnaire. This required that data to be used in assessments should be available or easy to gather. As shown in Appendix B, the only significant difference in response was between the industrialized countries of North America and the rest of the world. The regional averages were 3.29 for Canada, 3.3 for the United States, 3.68 for other industrialized nations, and 4.0 for the third world. This difference may be explained as follows. In the United States and Canada, an environmental data industry has sprung up. Thus, the manpower and equipment for generating rather specialized data is available, though not necessarily inexpensive. In the other countries, this "machinery" is not in place. Thus, the use of secondary data is more desirable.

Resource Allocation for Baseline Survey

In most cases, a baseline survey is constrained by finite resources of money, manpower and time. The question therefore arises as to how to allocate these resources to the various environmental elements which must be studied. Most often, allocation is done on a first-come, first-served basis. This is not a good approach, since it may yield misdirected results. Relatively unimportant elements may be the subject of extensive research, simply because they were identified early in the survey. On the other hand, critical elements may receive only cursory attention because they were considered late in the survey, after all resources had been depleted.

A more realistic approach is the weighting of elements by pairwise comparisons (Canter, 1981c). This approach can be especially useful if the weighting is done after the impact identification exercise. The following example will serve to illustrate how weighting by pairwise comparison is done.

> Background: Consider an environmental study on an industrial project. A total of $50,000 is available for the baseline survey. The allocation of technologist's time for this step of the environmental study is 120 man-hours. The impact identification process has been conducted, and changes are expected as follows:
>
> Air: 3 major impacts
> Water: 4 major impacts, 2 lesser impacts
> Other Physical/Chemical: 3 lesser impacts
> Wildlife: 1 major impact
> Socio-Economic: 4 major impacts, 6 lesser impacts
> Cultural: 1 lesser impact
>
> Step 1: Pairwise Comparison: Set up a matrix as in Figure VII.4. Systematically compare each pair of elements, scoring 1 for the element subject to greater impacts, and zero for the other element. Score 0.5 each if both elements are subject to similar levels of impacts. In this example, element 1 (air) faces fewer impacts than element 2 (water). Thus, a "1" is placed in column 2, row 1 of the matrix, and a "0" in column 1, row 2. Similarly, element 3 (wildlife) faces more severe impacts than element 6 (cultural). Therefore, a "1" is placed in row 3, column 6, and a "0" in row 6, column 3. A dummy element must be included to ensure that all viable elements receive a non-zero weighting.
>
> Step 2: Weighting Factors: The points awarded to each element are totaled across that element's row. These point totals are

No	Element	Pairwise Comparison With: 1	2	3	4	5	6	7		Point Total	Weighting Factor
1	Air	-	0	1	1	0	1	1	=	4	.19
2	Water	1	-	1	1	-	1	1	=	5	.23
3	Other Physical/Chemical	0	0	-	0	0	1	1	=	2	.1
4	Wildlife	0	0	1	-	0	1	1	=	3	.14
5	Socio-Economic	1	1	1	1	-	1	1	=	6	.29
6	Cultural	0	0	0	0	0	-	1	=	1	.05
7	Dummy	0	0	0	0	0	0	-	=	0	-
									Σ =	21	1

Figure VII.4: Element Weightings by Pairwise Comparsion.

summed together. As a check, the following relationship can be used:

Sum of point totals = (1/2) (n) (n-1),

where n = number of elements, including dummy.

The weighting factor for each element equals point total for that element divided by the sum of point totals. The sum of all weighting factors equals one.

Resource Allocation: The first approach to resource allocation would be to distribute resources in proportion to the weighting factors. Thus, in this case, the baseline study of the air environment would be allocated $9,500 ($50,000 x .19) and 23 man-hours (120 m-h x .19). Similarly, the study of existing socio-economic conditions would be allocated $14,500 ($50,000 x .29) and 35 man-hours (120 m-h x .29), etc.

Further Refinement: The above allocation formula assumes that data-gathering for all environmental elements has the same cost per unit of output. In fact, this is often not the case. If the relative costs of data-gathering are unknown, the above calculations represent a good first approximation of allocations. The computed figures must then be adjusted based on experience. If the relative costs of data-gathering are known, the weighting factors can be adjusted to include them. This is done as follows:

Let PT_i = point total for element i, and

RC_i = relative cost of data-gathering for element i, then

Weighting Factor for element i = $(PT_i)(RC_i)/\Sigma(PT_i)(RC_i)$.

In this example, assume that data gathering for air, water and other physical elements have the same relative cost; wildlife is twice as expensive as these; and socio-economic and cultural are only one and a half times as expensive. The new weighting factors, dollar and manpower allocations would be as follows:

Element	Point Total	Relative Cost	Weighting Factor	$ Allocation	Man-hours
1	4	1	.15	7,500	18
2	5	1	.18	9,000	22
3	2	1	.07	3,500	8
4	3	2	.22	11,000	26
5	6	1.5	.33	16,500	40
6	1	1.5	.05	2,500	6

Summary

There are not many methods which have been developed exclusively for use in describing the affected environment. Three potentially useful methods were presented in this section: a checklist, a matrix format, and a structured habitat approach. Of these, only the UNEP checklist was intended to be comprehensive.

Table VII.12 contains a summary of 14 methods (with references) which can be used during the planning and execution of the baseline study. The three methods which were described earlier in this section are included. The table is divided into three major sections. The first contains methods which are useful for the general planning of baseline studies. The second includes methods which are related to the baseline study of the biological environment. The final section relates to baseline studies for water projects. In addition to the methods listed in Table VII.12, checklists and matrices listed in Table VII.9 can also be useful in designing the baseline study.

It is very important that the layout of the baseline description be consistent with the other steps in the environmental study. Ideally, the baseline study should follow logically from the impact identification step, emphasizing those elements which are expected to be most seriously affected by the project. The baseline study should also build the foundation for the prediction of impacts. Specifically, data should be presented in such a form (and units) that it can be readily used in the various models and techniques that will be employed to quantify the level of impacts.

Table VII.12: Summary of Methods for Planning and Conducting the Baseline Study (Adapted from Canter, 1980)

Reference	Method and Application
A. GENERAL PLANNING	
*UNEP (1981)	Summary tables for siting of industry.
Marcus (1979)	Planning a monitoring program, including post-audits.
States, et al. (1978)	Planning for ecological baseline studies.
Stout, et al. (1978)	Planning integrated baseline studies.
James, Woods and Blanz (1976)	Use of LANDSAT to evaluate impoundment and channelization projects.
B. MONITORING THE BIOLOGICAL ENVIRONMENT	
*U.S. Army Corps of Engineers (1980)	The Habitat Evaluation System for rating habitat types.
*Canter (1981c)	A chart for cataloging data on habitat quantity.
Collotzi and Dunham (1978)	An approach for inventorying aquatic habitats.
Lee, Wang and Kuo (1978)	Use of community diversity index.
C. BASELINE STUDIES FOR WATER PROJECTS	
Dunnette (1979)	Index based on geographical characteristics of river basins.
Liebetrau (1979)	Statistical considerations.
Provencher and Lamontagne (1979)	Index based on water uses.
Reynolds (1975)	Index based on water uses and water quality objectives.
Yu and Fogel (1978)	Index based on user-oriented benefits and treatment costs.

*Indicates a method which was described in this section.

Comparison of Alternatives

An important step in an environmental study is the selection of one alternative for implementation. The selected alternative should be the one which delivers maximum benefits while minimizing adverse effects. Thus, the decision in most cases becomes a trade-off between merits and demerits of each alternative. In this section, several methods of comparing alternatives are discussed. These are systematic approaches, and a numerical basis is used for comparison. They are superior to ad hoc or "expert judgment" approaches, because they are less affected by special interest pressures.

Tiered Approach

One of the problematic choices associated with the selection of the proposed action is balancing the desire to consider as many alternatives as possible against cost. In order to include a large number of alternatives but still keep cost down, a tiered approach can be adopted. This involves a series of levels of comparison, each involving fewer choices and more technical detail than the last.

An example of the tiered approach is the environmental study which formed part of the Fort Carson Training land acquisition program (Fort Carson, Colorado, 1980). The selection process here included four steps. The first was a comparison between management measures to eliminate the need for more land, the no action alternative, and the acquisition of additional land. In the second tier, 21 non-contiguous but near-by sites were considered. Purchase of adjacent land was considered impractical. At the end of tier two, only 2 of the 21 sites were considered suitable for further study. Tier three involved the comparison of three management scenarios at each of the two suitable sites. The final tier was a direct comparison of the preferred scenario at each of the two suitable sites. Both sites were feasible, so the objective of the fourth tier was to select the better one.

The use of the tiered approach reduces the duration and cost of the comparison of alternatives while admitting a wide range of alternatives. Each successive tier employs more detailed environmental and engineering input. Also, infeasible alternatives are excluded at each tier. In this way, the final choice is based on a detailed study of the few most appropriate alternatives. A tiered approach was also used in the M-X program (Dept. of the Air Force, 1980).

Scaling Checklist for Siting an Industry

This method was developed by a Task Force in India, who were faced with the problem of selecting a site for a fertilizer plant on the Indian West Coast (Raman, Bowonder and Sundaresan, 1980). The approach was as follows:

(1) A list of factors was drawn up. In this specific case, the list contained 21 factors under 5 headings. These headings were Air Pollution, Water Pollution, Solid Waste, Human Habitat and Conservation. Table VII.13 lists the number of factors under each heading, and gives an example of each.

(2) Each site is graded for each of the factors on the list, using a scale of A to D. The interpretation of each of the grades is given in Table VII.13. In this system, the grade refers to both the quality of effluent and the assimilative capacity of the environment. For example, a receiving water that is already close to the allowable limit for a particular contaminant will result in a score of C or D, even if the project effluent is small. The

Table VII.13: Scaling Checklist for Siting an Industry (Raman, Bowonder and Sundaresan, 1980).

a. Factors Rated:

Heading (number of factors)	Example of Factor
1. Air Pollution (4)	Topography and Micrometerology
2. Water Pollution (6)	Circulation and dispersion pattern of receiving water
3. Solid Waste	Effect of leaching of ash and solid waste on nearby wells
4. Human Habitat	Displacement
5. Conservation	Vegetation

b. Grading System:

Grade	Interpretation
A	Excellent. Minimal adverse effects.
B	Fair. Some adverse effects.
C	Satisfactory or below par.
D	Unsatisfactory. Major problems anticipated.

c. Overall Impact Grading:

Parameter	Site		
	1	2	3
Air Pollution	C	C	A
Water Pollution	B	C	A
Solid Waste	C	B	B
Human Habitat	D	A	B^+
Conservation	C	A	C
Final Grading:	C	B	B^+

same effluent, discharged into a less-contaminated stream, will result in a score of A or B.

(3) The factor ratings under each heading are averaged for each site. These are transcribed onto a summary table like the one shown in Table VII.13.

(4) The ratings for the five headings are again averaged to give an overall grading for each site.

The major drawback in the system just described is its inability to discriminate between factors and headings of different importance. When factor ratings are averaged in step 3, and heading ratings in step 4, it is assumed that each factor or heading is equally important as all others. This may not be the case. Consider the final gradings in Table VII.13. If all headings are of equal importance, then Site 3 is the logical choice. However, if it is decided that air and water pollution are relatively unimportant but human habitat and conservation are of over-riding importance, then Site 2 should be chosen. Unfortunately, scaling checklists have no built-in mechanism for considering importance weights.

The Battelle Environmental Evaluation System

The Battelle Environmental Evaluation System (EES) is a weighting-scaling checklist which was developed to compare alternatives on water resource projects (Dee, et al., 1972 and 1973). Unlike the previous method, the Battelle EES does recognize differences in importance of different factors.

In the Battelle EES, the environment is divided into four main parts: ecology, environmental pollution, esthetics and human interest. Each of these parts is further broken down into classifications.

Ecology consists of terrestrial species and populations, aquatic species and populations, terrestrial habitats and communities and aquatic habitats and communities. Environmental pollution includes water pollution, air pollution, land pollution and noise pollution. Esthetics are composed of land, air, water, biota, manufactured objects and composition. Finally, human interest includes education/scientific packages, historical packages, cultures, mood/atmosphere and life patterns.

A total of 78 factors are distributed among the 19 classifications in the last paragraph. The number of factors in each classification, examples of factors, and the importance weights of factors, classifications and parts are listed in Table VII.14. The importance weight of a classification equals the sum of the importance weights of all factors in that classification. Similarly, the importance weight of a part equals the sum of the importance weights of all the classifications in that part.

The actual scaling of factors under each project alternative is done using scaling functions. These functions are graphs, tables or matrices which relate a particular measurement to an environmental quality scale. In the Battelle EES, these scales run from 0 to 1. An example of a graphical scaling function was previously presented in Figure IV.3. A tabular format is shown in Table VII.15.

When the Battelle EES is used, each project alternative is rated against all 78 factors, using the scaling functions just described. Each quality rating is multiplied by the appropriate

Table VII.14: Factors and Importance Weights for Battelle EES (Dee et al, 1972 and 1973)

Classification (# of Factors) Example Factor	Importance Weight
A. ECOLOGY	240
Terrestrial Species and Populations (4)	70
Crops	14
Aquatic Species and Populations (4)	100
Sport Fish	14
Terrestrial Habitats and Communities (4)	50
Land Use	12
Aquatic Habitats and Communities (4)	50
Food Web Index	12
B. ENVIRONMENTAL POLLUTION	402
Water Pollution (14)	318
BOD	35
Air Pollution (7)	52
Hydrocarbons	5
Land Pollution (2)	28
Soil Erosion	14
Noise Pollution (1)	4
Noise	4
C. ESTHETICS	153
Land (3)	32
Geologic Surface Material	6
Air (2)	5
Odor and Visual	
Water (5)	52
Water Surface Area	10
Biota (4)	24
Diversity of Vegetation	9
C. ESTHETICS (Continued)	
Manufactured Objects (1)	10
Manufactured Objects	10
Composition (2)	30
Composite Effect	15
D. HUMAN INTEREST	205
Educational/Scientific Packages (4)	48
Archeological	13
Historical Packages (5)	55
Architecture and Styles	11
Cultures (3)	28
Indians	14
Mood/Atmosphere (4)	37
Isolation/Solitude	11
Life Patterns (3)	37
Housing	13

Table VII.15: Scaling Function for Architecture and Styles

Historical Significance of Buildings to be Destroyed	Environmental Quality of Project Alternative
None	1
Low	0.4
Low/Medium	0.3
Medium/high	0.2
High	0.0

importance weight, and these products are summed to give the overall score for that alternative. Mathematically,

$$S_a = \sum_{\text{all } n} a_n W_n$$

where S_a = score for alternative a

a_n = quality of factor n under alternative a, and

W_n = importance weight of factor n.

When the scores for all alternatives have been calculated, the largest numerical value represents the most environmentally sound course of action.

The factors, weights and scaling functions of the original EES can be varied to make the system project- and site-specific. Toussaint (1975) has modified the system to make it applicable to water resource projects in the Southwestern United States. Lohani and Kan (1981) developed an EES for water resource projects in Thailand based on the Battelle system. The basic methodology can also be adapted for comparing other types of projects.

The Optimum Pathway Matrix

This method was developed in order to compare a series of alternative routes for a highway (Odum, et al., 1971). Although the results are displayed as a matrix, the underlying methodology is actually a weighting-scaling checklist. Unlike the Battelle EES, though, this method does not use scaling functions.

The first step in the optimum pathway matrix (OPM) method was the selection of indicators which would be used to evaluate the various alternatives. A total of 56 indicators were chosen, 8 of which are listed in the first column in Table VII.16. (This table is a simplified example of the use of the OPM). The 56 indicators came from 4 general groups: economics and highway engineering, environment and land use, recreation, and social and human factors. Data was collected or projected on each indicator for each project alternative. This data appears in the "measured value" column of Table VII.16. In the example, alternative 1 requires 20 acres of cropland, 40 acres of idle land and 40 acres of urban land for right-of-way. Similarly, alternative 3 is estimated to save 20 lives in the short-term and 90 in the long-term.

The second step involved unitizing the scale values for each indicator and alternative. In the OPM, this is done by assigning unit value to the largest numerical measurement for any indicator, and computing the values for other alternatives by simple factors. Thus,

$$U_{ij} = X_{ij}/(\max X_i)$$

where U_{ij} = unitized value for indicator i, alternative j,

X_{ij} = measured value for indicator i, alternative j, and

$\max X_i$ = maximum measured value for indicator i.

In Table VII.16, the unitized values are listed in the last three columns. In the case of water supplies affected, the maximum X_i was 3. Thus, the unitized values were 3/3, 2/3 and 1/3 for alternatives 1, 2 and 3 respectively.

The third step involved the assignment of importance weights to all indicators. Relative weights were assigned for short-term and long-term impacts on a scale of +50 to -20 (see columns 2 and 3 of

Table VII.16: Optimum Pathway Matrix Layout

INDICATOR	Relative Weights		Composite Weight	Measured Value			Unitized Value		
	Short Term	Long Term		Alt 1	Alt 2	Alt 3	Alt 1	Alt 2	Alt 3
Acres removed for right-of-way:									
Crops	- 3	-10	- 9.36	20	60	15	.33	1	.25
Idle	+ 5	+ 8	7.73	40	10	80	.50	.13	1
Urban	- 6	+10	8.55	40	30	5	1	.75	.13
Water Supplies Affected	- 2	0	- .18	3	2	1	1	.67	.33
Schools Affected by Noise:									
Some Impact	- 3	- 3	- 3	0	0	2	0	0	1
Great Impact	-10	-10	-10	3	2	2	1	.67	.67
Lives Saved:									
Short Term	+50	0	+ 4.55	5	15	20	.25	.75	1
Long Term	-	+50	+45.45	100	80	90	1	.8	.9

Table VII.16). The actual assignment of weights was done by an interdisciplinary team. A composite weight was then computed for each indicator. This was done by assuming that short-term impacts were only one-tenth as important as long-term ones. That is,

$$W_{ci} = 1/11\ (W_{si} + 10W_{Li})$$

where W_{ci} = cumulative weight for indicator i,

W_{si} = weight of short-term impacts on indicator i, and

W_{Li} = weight of long-term impacts on indicator i.

The fourth step involved the computation of unitized weighting values. For any factor/alternative combination,

$$N_i = W_{ci}/(\sum_{\text{all } i} W_{ci})$$

where N_i = unitized weighting value for indicator i, and

W_{ci} as before.

The fifth step of the OPM was the calculation of an environmental index for each alternative. This was done by multiplying the unitized values by the unitized weighting values, and summing the products. Hence,

$$I_j = \sum_{\text{all } i} (N_i U_{ij} \pm e\ N_i U_{ij})$$

where I_j = environmental index of alternative j,

e = a random error term within the limits $\pm$ 50%, and N_i, U_{ij} are as before.

An important feature of this approach is the inclusion of the error term, which allows for misjudgment of the relative importance of indicators. These terms can be obtained from random number tables.

For example, if two digit random number tables are used, then the error terms can be set as:

e = (number from table - 50)%

This would randomly distribute the numbers between -50% and +50%.

In the original OPM study, each alternative was analyzed 20 times, using a different set of error terms each time. This produced twenty environmental indices for each alternative. From these 20 numbers, the mean, standard deviation and 95% confidence interval were calculated, assuming a normal distribution. The comparison of alternatives was based on the mean and confidence intervals for each alternative. Generally, the alternative with the largest mean is selected. However, if there is considerable overlap between 95% confidence intervals for two or more alternatives, further investigation may be warranted.

One drawback of OPM is the fact that its scaling system cannot handle non-numerical indicators. Thus, such indicators as aesthetics cannot be included in the evaluation because they are not numerical. The next method, also a weighting-scaling checklist, solves this problem by using a pairwise comparison technique.

Water Resources Assessment Method

The Water Resource Assessment Method (WRAM) was developed for use on water resource projects of the U.S. Army Corps of Engineers (Solomon, et al., 1977). It differs from the Battelle EES and the OPM in two ways. First, it presents several means of scaling impacts. Second, it contains a systematic method for assigning importance weights to variables chosen for a particular project. The steps in the method are as follows.

Selection of Variables: In WRAM, the overall project is divided into four accounts: national economic development, environmental quality, social well-being and regional development. Each account consists of divisions, and each division contains variables. The accounts, divisions and example variables are listed in Table VII.17. For the water resource development being planned, a project-specific list of variables must be drawn up, including the relevant variables in each division and account.

Impact Scaling: Three alternative methods of impact scaling are presented. The first is the use of scaling functions as was done in the Battelle EES (see Figure IV.3 and Table VII.15). These functions convert predicted impacts to quality index values.

The second method of scaling impacts is a linear method similar to that used in OPM. It can be applied to numerical impact predictions.

$$\text{Quality Index (QI)} = (V_i - \min V)/(\max V - \min V)$$

where V_i = value of impact caused by alternative i,

min V = value of minimum impact among all alternatives, and

max V = value of maximum impact among all alternatives.

The third scaling method is a pairwise comparison. This can be used to scale impacts which are predicted on a qualitative basis. The method is shown in Table VII.18. In that example, the impacts have been predicted as shown. When alternatives A and B are compared, A is

Table VII.17: Accounts, Divisions and Example Variables for the WRAM

Account Division	Example Variables
NATIONAL ECONOMIC DEVELOPMENT	
Project Efficiency (Beneficial)	Increased Output
Project Efficiency (Adverse)	External Diseconomies
ENVIRONMENTAL QUALITY	
Terrestrial	Pests
Aquatic	Water Quality
Air	Chimatology
Human Interface	Historical
SOCIAL WELL-BEING	
Real Income Distribution	Income Generated
Life, Health and Safety	Pathogens
Education, Culture, Recreation	Opportunities
Emergency Preparedness	Resources
Demographic Characteristics	Migration
Community Organization	Displacement
Noise	
Aesthetic Values	
REGIONAL DEVELOPMENT	
Income Effects	User Payments
Employment	Long Term Jobs Created
Population Distribution	Composition
Economic Base and Stability	
Environmental Effects of Regional Concern	
Regional Effects on Education, Culture and Recreation	

Table VII.18: Scaling Impacts on Variable "i" Using Pairwise Compairsons

a. Impact Predictions:

Alternative	Predicted Impact
A	beneficial
B	adverse
C (dummy)*	very adverse
D (no action)	none

* by definition, the dummy is the least desirable alternative.

b. Scaling

Alternative:	With Alternative: A	B	C	D	Total Points	ACC
A	-	1	1	1	3	0.5
B	0	-	1	0	1	0.17
C	0	0	-	0	0	0.00
D	0	1	1	-	2	0.33

$\Sigma =$ $\underline{6}$

superior since it has a beneficial impact while B has an adverse impact. A "1" is therefore placed in row 1, column 2, and a zero in row 2, column 1. This comparison is done for each pair of alternatives, and points awarded accordingly. If two alternatives have the same impacts, they are each awarded 0.5 points. The points for all alternatives are totalled across the rows. These totals are then summed, as shown in the penultimate column. The ACCs are then determined by dividing the total points for each row by the sum of the totals.

If either of the first two scaling methods is used, it is necessary to convert the quality indices to Alternative Choice Coefficients (ACCs) before they can be used in WRAM. This is done as follows. For a given variable, i, the quality indices for all alternatives are determined. If I_{ij} represents the quality index for the impacts of alternative j on variable i, then:

$$ACC_{ij} = I_{ij} / \sum_{\text{all } j} I_{ij}$$

where ACC_{ij} = alternative choice coefficient for the impacts of alternative j on variable i.

Weighting: Importance weighting is done at two levels. The variables are weighted within each account, and accounts are weighted for the final comparison. In both cases the pairwise comparison is used. All the variables in an account are arranged in order of importance. A dummy variable is included to ensure that all real variables receive an importance weight. This dummy is the lowest priority, and represents a "least important" variable. A pairwise comparison is then conducted, using the same procedure as in Table VII.18. The points are totalled for each variable, and each total is divided by the sum of the totals. These are the Relative Importance Coefficients (RICs) for the variables. An example of RIC computation is shown in Table VII.19.

The third matrix in Table VII.19 shows how the RICs and ACCs for all variables and alternatives in one account are used to rank the alternatives in order of preference. In Table VII.19c, the variables in the account being considered are listed in the first column, and the RICs for these variables in the second column. The ACCs for the three alternatives (from Step 2) are listed in the next three columns. The final coefficients are the products of the RICs and ACCs. These are listed in the last three columns. These final coefficients for each alternative are totalled. These totals can be used to rank the alternatives for the account under consideration. The alternative with the highest total is the "best" alternative for that account, the second highest total represents the next best alternative, and so on.

The final task of WRAM is the comparison of alternatives based on all accounts. This is done by computing RICs for accounts and ACCs for accounts and alternatives. The RICs are computed as in Table VII.19b, except that the importance of accounts are compared instead of variables. The ACCs are computed just as they were in Table VII.18, except that the comparison is based on alternative impacts on accounts, rather than variables. Thus, the second column in Table VII.18a would list the preference order obtained from Table VII.19c. The overall comparison is analagous to Table VII.19c. The first column would list

Table VII.19: RICs and Final Matrix for a WRAM Account.

a) Variable Importance in Account

Variable	Importance Rank
A	1
B	2.5 (Tie)
C	4
D	2.5 (Tie)

b) Relative Importance Coefficients for Variables in Account

Compare Variable:	With Variable: A	B	C	D	Dummy	Total Points	RIC
A	–	1	1	1	1	4	.40
B	0	–	1	.5	1	2.5	.25
C	0	0	–	0	1	1	.10
D	0	.5	1	–	1	2.5	.25
Dummy	0	0	0	0	–	0	0
						$\Sigma = 10$	

c) Final Matrix for Account

Variable	RIC	ACCs Alt 1	ACCs Alt 2	ACCs Alt 3	Final Coeff. = (RIC)(ACC) Alt 1	Alt 2	Alt 3
A	.40	.67	.33	0	.27	.13	0
B	.25	.33	.33	.33	.08	.08	.08
C	.10	.5	0	.5	.05	0	.05
D	.25	.33	.67	0	.08	.17	0
				TOTALS	.48	.38	.13

accounts, not variables, and the RICs and ACCs would be those calculated for accounts. The ranking of alternatives would be based on final coefficient totals, as was done before.

USAID Matrix

The USAID checklist for identifying the impacts of rural development projects was introduced in the section on Impact Identification. After impacts have been identified and quantified, they can be displayed on an interaction matrix. Figure VII.5 is a very simplified example of the format suggested by USAID.

A separate matrix is drawn for each project alternative. The horizontal axis lists project actions, and the vertical axis environmental factors. At each intersection, the impact (if any) of that action on that environmental factor, is shown. Large and small empty circles represent major and minor beneficial impacts, respectively. Shaded circles represent adverse impacts. A blank intersection implies no impact. Multiple impacts are shown using a dual symbol. An example is shown in Figure VII.5. Action 7 has a major beneficial effect and a minor adverse effect on factor B. Multiple impacts can occur, for example, when short-term effects differ from long-term ones.

The comparison of alternatives is done visually. The matrices for the various alternatives are viewed together, and the choice is based on the judgment of the person doing the comparison. It should be noted that subjectivity is one of the limitations of this method. The assignment of a "major" or "minor" classification to an impact is a

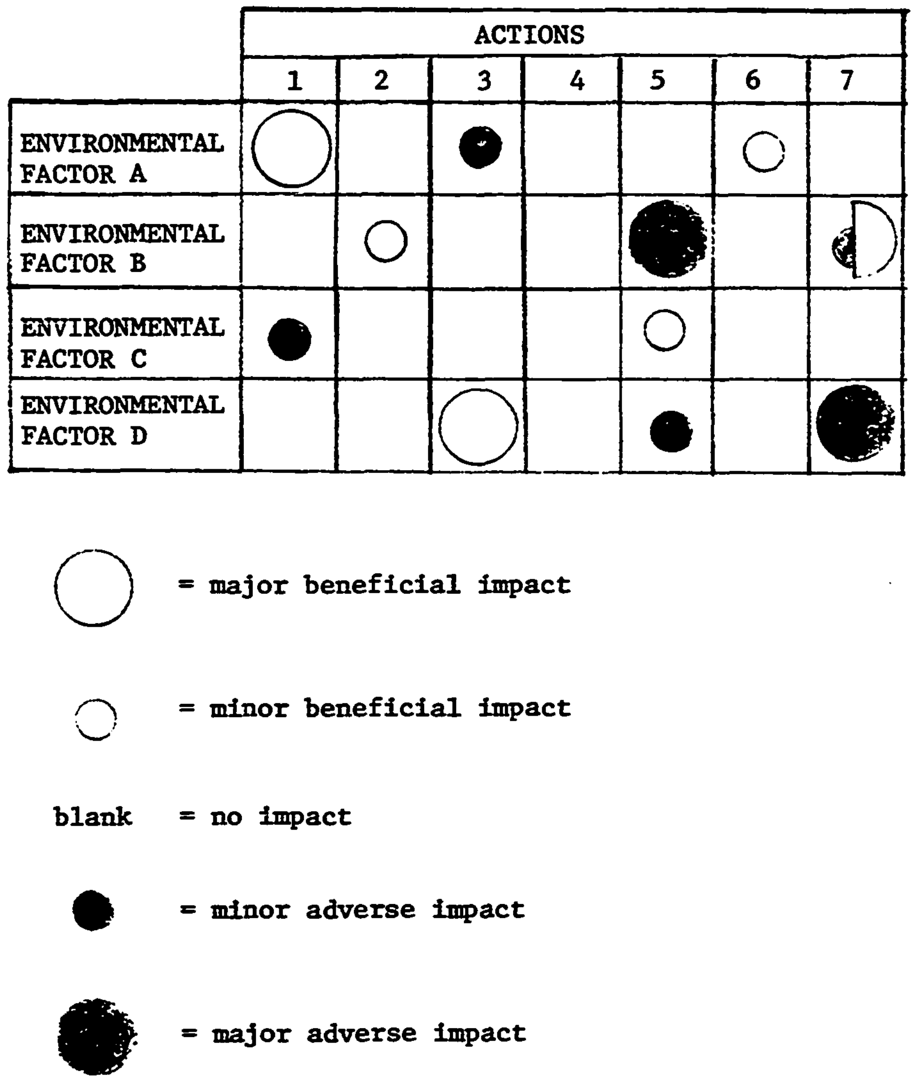


Figure VII-5: Display of Impacts from One Project Alternative on AID Matrix (U.S. AID, 1981) judgment decision, as is the final trade-off of benefits and demerits in selecting the proposed action. In spite of this, the USAID matrix does provide a simple approach to deciding on a project alternative. It presents a clear summary of predicted impacts and can be effective on small projects or parts of large projects.

Leopold Matrix

This method was introduced earlier, in the section on impact identification. It can also be used to compare project alternatives. As with the USAID method just described, a seperate Leopold matrix will have to be drawn up for each project alternative. These matrices would then be compared to determine which alternative should be adopted. The procedure for completing the matrix is as follows (Leopold, et al., 1971).

1. Assemble Matrix: During the impact identification exercise, the interactions between project actions and environmental items would have been investigated. A project-specific matrix can be drawn up based on the original Leopold lists of actions and factors. Those actions which are not relevant to the project under consideration, or which do not cause any impacts, are deleted. Similarly, those environmental items which are irrelevant to the project area or which are unaffected by the project are deleted. On the other hand, additional actions and items which are relevant must be included. The project-specific matrix can then be used to evaluate all project alternatives.

2. Rate Impact Magnitude: The magnitude of an impact refers to the extensiveness of the effect. This is rated on a scale of 1 to 10, where 1 represents an impact over a limited area, and 10 represents a very extensive impact. The assignment of rating numbers is based on the predicted extent of the impact. Some value judgment does come into play, however, since "extent" depends upon the actual impact being discussed. For example, the destruction of ten acres of a particular habitat type may be considered extensive; but an increase in atmospheric CO concentration

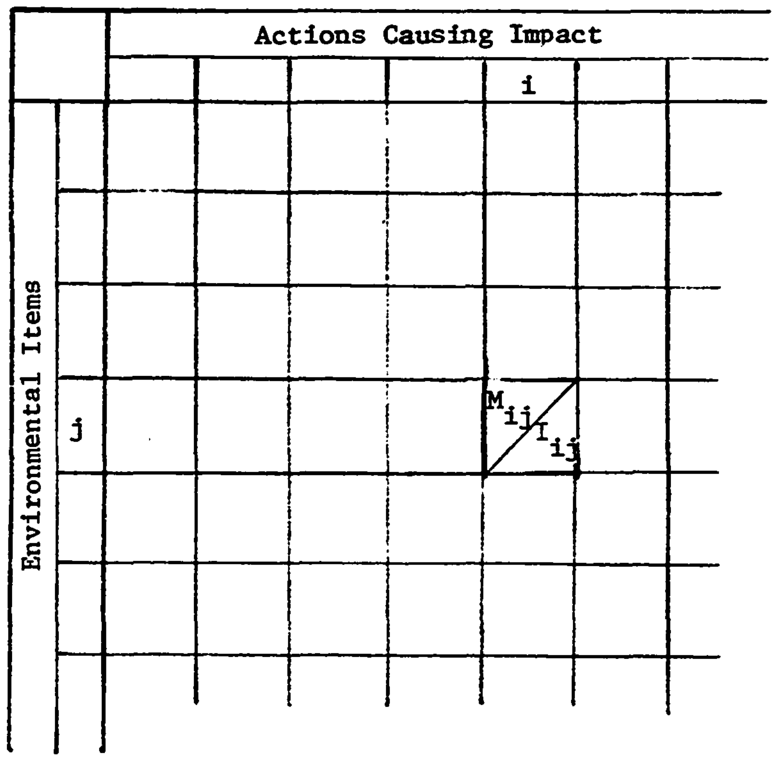
within a ten-acre area of a city may not. The rating of impact magnitude for each action/item pair is indicated on the matrix as shown in Figure VII.6.

3. Rate Impact Importance: The importance of an impact relates to the degree of change involved, and hence the consequences of the change. In the original Leopold matrix, the rating was on a scale of 1 (minor importance) to 10 (great importance) and addressed only adverse impacts. An improvement is the use of a scale from +5 (very important beneficial impacts) to +1 (beneficial impacts of minor importance), and -1 (adverse impacts of minor importance) to -5 (major adverse impacts). The inclusion of both types of impacts facilitates the comparison of alternatives. As before the importance rating should be based on the predicted degree of change. But also as before, there is some subjective judgment since the consequences of a given percentage of change varies depending on the impact. Impact importance ratings are displayed as shown in Figure VII.6.

4. Compare Alternative Matrices: When matrices for all alternatives, these are compared to select a "best" choice. Basically, this is done by inspection. However, there are several approaches which can be used to assist in the process. Simply summing the numbers of rows or columns which are designated as having interactions will give an indication of which alternatives produce more effects, and which produce less. Examining the distribution of magnitude ratings for each alternative gives an idea of how many of the impacts are large-scale. And examining the distribution of importance ratings for each alternative will show what proportion of the impacts are minor, and what proportion are critical.

Suriyakumaran's Cost-Benefit Analysis

The basic thesis upon which this method rests is that all projects can be summarized as an outflow of resources and an inflow of benefits (Suriyakumaran, 1980). Any project can therefore be analyzed as a cost-benefit problem, and the various alternatives can also be compared on this basis. This cost-benefit method can best be explained by an example. The one which was chosen is an irrigated forest farm in Vatava, Gujarst State, India. The project involved the conversion of a



M_{ij} = magnitude of impact on item j caused by action i.

I_{ij} = importance of impact on item j caused by action i.

Figure VII.6: Rating of Magnitude and Importance of Impacts on the Leopold Matrix cotton plantation to an eucalyptus forest. The project involves a ten-year cycle. During the first year, both cotton and eucalyptus would be planted. The cotton is reaped and the stalks removed during the second year, leaving the eucalyptus in sole possession of the forest. After seven years, the forest is thinned. Finally, after ten years, the eucalyptus trees are felled and the cycle is restarted. In each of the ten years, grass is reaped and eucalyptus seeds collected.

Table VII.20 shows the cost-benefit presentation for this project. It lists a total of 25 items: 13 costs and 12 benefits. Costs and benefits are reported in United States dollars. In any cost-benefit analysis, the monetary units reported must be on a common basis. In this case, the figures were converted to present value. In other studies, they may be converted to an annual expenditure. When present values are used, initial capital outlays are taken at face value, and future capital outlays as well as operating and maintenance are discounted to present at an appropriate interest rate. Incomes are also discounted to present value. In this example, land cost is an initial expenditure, value of cotton is a series of future incomes, and irrigation involves both initial expenditure and a series of future expenditures.

A second set of decisions in this method relates to the question, "what is a benefit, and what is a cost?" In this example, payment to workers is listed as a benefit, since India has an unemployment problem. In other countries, it may be argued that worker wages is a cost, since it involves a cash outlay from the project. Yet

Table VII.20:Cost-Benefit Presentation for Vatava Irrigated Farm Forest, Gujarat State, India (Suriyakumaran, 1980)

ITEM	Cost US$	Benefit US$
Land	41,186	
Eucalyptus seedlings	8,000	
Irrigation (eucalyptus)	27,852	
Fertilizers and manure (eucalyptus)	38,671	
Pesticides and insecticides (eucalyptus)	2,000	
Bacterial Culture and trace elements	110	
Cotton seed	1,926	
Fertilizers (cotton)	24,861	
Pesticides (cotton)	10,115	
Irrigation (cotton)	7,167	
Labor (eucalyptus)		129,405
Labor (cotton)		27,568
Cowdung manure saved		20,860
Crop damage in nearby fields	4,172	
Expanded employment (spinoff industries)		150,973
Value of eucalyptus trees		417,216
Value of eucalyptus seed		5,917
Value of cotton		11,546
Value of grass		73,000
Value of eucalyptus wood from thinnings		120,244
Savings in land preparation		15,616
Eucalyptus stumps after felling		15,616
Cotton stalks after harvest		730
Exhausted soil fertility	41,186	
R & D (optimization of crops)	16,324	
	223,570	1,007,708

another approach would be to list wages as both a cost (to the project) and a benefit (to society).

A third question is whether potential earnings lost and potential savings should be included. In this example, a figure is included for manure saved. This represents the value of manure which would have been used had the acreage remained as a cotton field. Since this is included, it seems logical that the potential earnings had the field remained under cotton should have been included.

A fourth consideration is the valuation of social, biological and cultural effects. These do not arise in the example cited, but they have been included in analyses using this method. For example, in a study of an industrial development in Thailand, a value was placed on the improvement of quality of life for workers and their families moving to the new area. The assignment of such values is never easy, and can lead to great controversy. Economists have responded to this situation by developing several techniques for evaluating extra-market costs and benefits (Hyman, 1981). The basic approaches are economic surrogates, supply-side approaches, hypothetical valuation, tradeoff analysis, valuation of human lives and threshold analysis. Economic surrogates include the related expenditures approach, the travel cost approach, the unit-day value method, the property value approach and the wage differentials approach. Supply-side approaches include replacement costs and defensive expenditures, and the alternative cost approach. Hypothetical valuations include bidding games and estimation games. Table VII.21 compares these approaches in terms of theoretical validity, reliabiiity and unbiasedness and ease of data collection.

Table VII.21: Comparison of Methods for Valuation of Extra-Market Costs and Benefits (from Hyman, 1981).

Approach	Theoretical Validity	Reliability and Unbiasedness	Ease of Data Collection	Applicability in EIA
Related Expenditures	L*	M	L	L
Travel Cost	H	H	H	H
Unit-Day Values	L	L	H	L
Property Values	M	H	M	H
Wage Differentials	L	H	H	M
Replacement Costs	H	H	H	H
Defensive Expenditures	H	H	M	H
Alternative Costs	L	H	H	M
Bidding Games	H	L	M	M
Use Estimation Games	M	L	M	M
Tradeoff Analysis	H	M	L	M
Human Capital Approach	M	M	H	M
Threshold Analysis	M	H	H	H

*H = high, M = medium, L = low.

The applicability of each approach in EIA is also rated. In this context, applicability refers to the relative frequency with which a particular approach would be expected to be used.

The final aspect of the use of cost-benefit analysis is the actual comparison of alternatives. Assuming that a cost-benefit tabulation has been done for each alternative, there are several ways to choose among them. The first is simply to select the one with the greatest Benefit/Cost ratio. If none has a Benefit/Cost ratio greater than 1, then the project is uneconomical. The problem with this approach is that it does not consider the actual cost of the project. Thus, a project may be done by a very expensive alternative when a cheaper alternative is available. The second approach is to select the least expensive of the alternaives which have a Benefit/Cost ratio greater than 1. This approach selects the most inexpensive of those alternatives which are economically viable.

A third approach is the incremental benefit/cost method (AASHTO, 1977). This is done as follows. All alternatives with a Benefit/Cost ratio less than 1 are excluded. All alternatives with a financial requirement exceeding the project budget are also excluded. The remaining alternatives are ranked in order of increasing cost (see Table VII.22). Each pair is compared using incremental Benefit/Cost. Between A and B, the cost increases by 1, and the benefit by 2. Thus, (Benefit/ Cost) exceeds 1. A is therefore rejected. B is then compared with C. In this case, (Benefit/ Cost) is less than 1. Thus, C is rejected. In general,

Table VII.22: Incremental Cost-Benefit Method of Choosing Between Alternatives

ALTERNATIVE	COST	BENEFIT	$\frac{\text{BENEFIT}}{\text{COST}}$
A	10	12	1.2
B	11	14	1.3
C	13	14	1.1
D	17	17	1.0
E	18	20	1.1
F	20	24	1.2

Compare A and B: $\frac{\Delta \text{ Benefit}}{\Delta \text{ Cost}} = \frac{2}{1} > 1$ reject A

Compare B and C: $\frac{\Delta \text{ Benefit}}{\Delta \text{ Cost}} = \frac{0}{2} < 1$ reject C

Compare B and D: $\frac{\Delta \text{ Benefit}}{\Delta \text{ Cost}} = \frac{3}{6} < 1$ reject D

Compare B and E: $\frac{\Delta \text{ Benefit}}{\Delta \text{ Cost}} = \frac{6}{7} < 1$ reject E

Compare B and F: $\frac{\Delta \text{ Benefit}}{\Delta \text{ Cost}} = \frac{10}{9} > 1$ reject B

<u>ACCEPT ALTERNATIVE F</u>

reject lower-cost alternative if ΔBenefit/ΔCost > 1, and
reject higher-cost alternative if ΔBenefit/ΔCost < 1.

The alternatives listed on Table VII.22 demonstrate the importance of the decision rule used. Based on the highest Benefit/Cost ratio, alternative B would be chosen. The least expensive alternative with a benefit/cost ratio greater than 1 is A. The choice based on incremental benefit/cost is F, even though it is the alternative with the highest cost.

Method for Balancing Cost and Environmental Priorities

This method was included in an approach to interdisciplinary site selection (Bell, Detre and Smedley, 1979). The basic idea is to make a choice based on both the financial costs and the environmental priority of alternatives. This method is applied after the financial costs of project alternatives have been estimated, and after the alternatives have been ranked in order of environmental preference by some other method. In the referenced article, the environmental ranking was done using a weighting-scaling checklist. However, other methods can be used. The alternatives are then plotted on a graph of project cost against environmental ranking, as shown in Figure VII.7. The direction of decreasing preference is as shown: in this case, alternatives B and C. This method is very useful when a large number of project alternatives are being compared. Although it may not yield a clear "preferred alternative", it can certainly be used to identify the two or three best alternatives for further study.

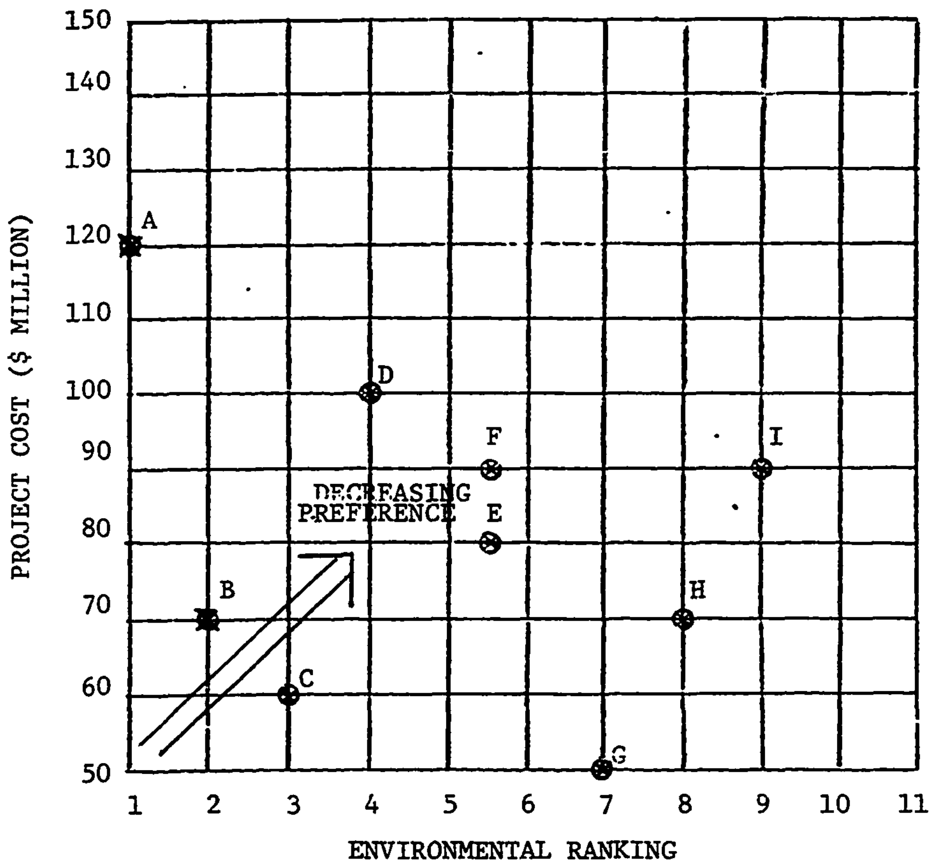


Figure VII.7: Balancing Cost and Environmental Priority

Comparing the Aesthetics of Alternative Sites

A quantitative method was developed for comparing the aesthetics of rivers (Leopold, 1969), and this can be generalized to comparing alternative sites for other types of projects. The basic concept is that landscape which is unique has more significance to society than that which is common. The evaluation of each alternative is done using a "uniqueness ratio", and the most unique sites are considered the least likely candidates for disturbance. The evaluation consists of five steps.

<u>Step 1</u>: A project-specific list of factors to be evaluated is drawn up. The factors used to compare rivers came from three groups: physical, biological/water quality and human use/interest. The number of factors in each group and examples of these factors is shown in Table VII.23.

<u>Step 2</u>: For each factor, a number of categories must be decided upon. For river sites, each factor was divided into five categories. Examples of these categories are shown in Table VII.23.

<u>Step 3</u>: Each site (alternative) is evaluated in terms of each factor. This is shown on Table VII.24a. In that example, alternative 1 is in category 1 of factor 1, alternative 3 in category 5 of factor 6, etc.

<u>Step 4</u>: For each alternative/factor combination a uniqueness ratio (UR) is calculated. This is the inverse of the number of sites in the same category for the factor under consideration. In Table VII.24b factor 1/alternative 1 has a UR of 0.5, since two sites are rated "1" under factor 1. Similarly, the UR of factor 3/alternative 3 is 0.33, and the UR of factor 2/alternative 4 is 0.25.

<u>Step 5</u>: The relative uniqueness of each site is the sum of all the URs in that column. The most unique site is the one with largest relative uniqueness. In the example on Table VII.24 alternative 4 is the most aesthetically significant, followed by alternative 3. Alternatives 1 and 2 are tied as least aesthetic.

Table VII.23: Factors Used to Compare the Aesthetics of Rivers

a. Groups and Example Factors

GROUP	NO. OF FACTORS	EXAMPLES
Physical	14	River width at low flow, flow variability, bed slope, basin area
Biological/Water Quality	14	Color of water, turbidity, river fauna
Human use/Human interest	18	Vistas, Land use, urbanization

b. Examples of Categories

FACTOR	1	2	3	4	5
River Width at Low Flow (feet)	< 3	3 to 10	10 to 30	30 to 100	> 100
Bed Slope (feet per foot)	.0005	.0005 to .001	.001 to .005	.005 to .01	> .01
Color	Clear		Green tints		.Brown
Turbidity (mg/1)	< 25	25 to 150	150 to 1,000	1,000 to 5,000	> 5,000
Vistas	open				closed
Urbanization	no buildings				many .buildings

Table VII.24: Uniqueness Ratios and Relative Uniqueness

a. Evaluation of Alternatives

	CATEGORY			
FACTOR	Alt 1	Alt 2	Alt 3	Alt 4
1	1	1	2	3
2	4	4	4	4
3	3	3	3	1
4	5	1	2	3
5	2	1	2	1
6	3	4	5	1

b. Uniqueness Ratios

FACTOR	Alt 1	Alt 2	Alt 3	Alt 4
1	.5	.5	1	1
2	.25	.25	.25	.25
3	.33	.33	.33	1
4	1	1	1	1
5	.5	.5	.5	.5
6	1	1	1	1
RELATIVE UNIQUENESS:	3.58	3.58	4.08	4.75

Evaluation of Methods

Five of the criteria which were rated by respondents to the questionnaire related directly to the comparison of alternatives. These were objectivity, flexibility, implementation, comparisons and public involvement. Objectivity requires a minimum of subjective input and immunity to political or other interference. Flexibility is the quality of being adaptable to projects of different sizes and types. The implementation criterion seeks to ensure that a method is not overly complex, costly or time consuming. The method should permit direct comparisons between alternatives, preferably on a numerical basis. And finally, in the content of comparing alternatives, public involvement is the input of local social and other values.

The importance ratings of these five criteria are analyzed in Appendix B. In no case were there significant differences among the third world responses. Therefore, these replies were pooled and used in a scaling-weighting comparison of seven methods of comparing alternatives. The actual importance ratings are shown in Table VII.25. Objectivity, flexibility and implementation were rated very important, while comparisons and public involvement were rated between average and very important. The evaluation of methods was based on the same approach that was described in the section on impact identification. The scores and final ranks are shown in Table VII.25.

The total scores fall naturally into three groups. The two scaling-weighting checklists are the most appropriate for use in the third world. Both comply well with all five criteria, WRAM being somewhat weaker in implementation but stronger in flexibility (which is

Table VII.25: Evaluation of Methods of Comparing Alternatives

Criteria:	Object-ivity	Flexib-ility	Implemen-tation	Compar-isons	Public Involve-ment	Total Score= Σ(IW)(CS)	Rank
Criteria Importance Weight (IW)	4.7	4.06	4.17	3.59	3.64		
METHOD	Compliance Scores* (CS)						
Indian Task Force Checklist	2	3	4	1	1	44.43	6
Battelle EES	3	3	3	3	3	58.89	2
Optimum Pathways Matrix	4	2	1	3	2	47.02	5
Water Resources Assessment Method (WRAM)	3	4	2	3	4	62.42	1
USAID Matrix	3	3	4	1	1	48.60	3
Leopold Matrix	3	3	3	1	2	48.07	4
Suriyakumaran's Cost-Benefit Analysis	1	3	2	3	2	42.74	7

*Criteria Compliance Scores: 0 = non-compliance, 1 = marginal compliance, 2 = moderate compliance, 3 = good compliance, 4 = excellent compliance.

built-in) and public involvement. The next group includes the three matrices. USAID and Leopold are both weak on comparisons and public involvement. The Optimum Pathway Matrix does make comparisons on a numerical basis. However, it is weak on flexibility, implementation and public involvement. In the case of implementation, the need for a computer to do the random error analysis could be a major drawback in the poorest countries. The lowest-ranked methods were the Indian Task force scaling checklist and Suriyakumaran's Cost-Benefit Analysis. The former is very easy to implement, but scores badly on objectivity, comparisons and public involvement. The latter is weak in implementation and public involvement. But the major problem is objectivity. The assignment of an impact as a cost or a benefit is solely at the discretion of the analyst. Thus, a great deal of subjective judgment is involved.

The methods for balancing costs and environmental priorities and the method for comparing the aesthetics of sites were not included in this comparison. This is because these two methods are not intended to be applied by themselves. Instead, both are designed for use in conjunction with other methods.

Summary

In this section, a total of nine methods for comparing project alternatives have been presented. This first was a scaling checklist, and the next three were weighting-scaling checklists. Two matrix methods and a cost-benefit method were also discussed. The penultimate technique was a method of balancing cost and environmental priorities, which is used in conjunction with one of the methods of comparing environmental attributes of alterantives. The final method is specific to comparing the aesthetics of alternative sites.

The methods of comparing alternatives were ranked based on the importance rating of five criteria. The scaling-weighting checklist methods were found to be most appropriate for comparing project alternatives in developing countries. Matrix methods were ranked next. The scaling checklist and the cost-benefit approach were found to be least appropriate at the present time.

Table VII.26 lists 21 methods (with references) which can be used to compare alternatives. The table is divided by methodology, and includes the 9 methods discussed in this section. In addition to these 20 methods, there are 17 checklists and 10 matrices in Table VII.9, and 5 index methods in Table VII.12, all of which are potentially useful in comparing alternatives. The methods of Duckstein, et al. (1977), and Rubenstein and Horn (1978) deserve special note. These introduce the concepts of risk and uncertainty into the assessment process. Since the predicted impacts of a given project are by no means certain, it is likely that these concepts will play a greater role in future assessments.

Each of the methods presented has benefits and demerits. What is important is that a systematic and impartial method be used to compare project alternatives. When a large number of alternatives or impacts is involved, the lack of a systematic method can lead to data being ignored during the final evaluation of trade-offs to select an alternative. The need for impartiality comes from the basic premise of

Table VII.26: Summary of Methods for Comparing Alternatives (Adapted from Canter, 1980)

Reference	Description
CHECKLISTS	
*Raman, Bowonder and Sundaresan (1980)	Scaling checklist for siting an industry.
*Dee, et al. (1972 and 1973)	Weighting-scaling checklist for water resources projects.
*Solomon, et al. (1977)	Weighting-scaling checklist for water resources projects.
Coastal Environments Ltd. (1976)	Checklist for evaluating on-shore impacts of off-shore oil and gas development.
Gertz (1978)	Ranking checklist analyzed using non-parametric statistics.
Yapijakas and Molof (1981)	Method for evaluating alternatives for a multi-national river basin development.
	Note: 17 other checklists are listed in Table VII.9.
MATRICES	
*Odum, et al. (1971)	Matrix display for highway route selection.
*USAID (1980)	Matrix summary of the impacts of rural development.
*Leopold, et al. (1971)	General interaction matrix.
Davos (1977)	Priority trade-off scanning using 3 types of matrices.
Herzog (1973)	Dynamic matrix for assessing the impacts of technological change.
Budge (1981)	Matrix and ordinal ranking of alternatives for water resource projects.

Table VII.26 (continued)

Reference	Description
	Note: 10 other matrices are listed in Table VII.9
OTHER METHODOLOGIES	
*Suriyakumaran (1980)	Cost-benefit approach.
*Leopold (1969)	Scaling checklist for comparing the aesthetics of rivers.
*Bell, Detre and Smedley (1979)	Graphical approach to balancing costs and environmental priorities.
Bohm and Henry (1979)	Combination of cost-benefit analysis and environmental considerations.
Schwind (1977)	Cost-benefit comparison of alternative land uses, with results displayed as a matrix.
Duckstein, et al. (1977)	Methodology for including uncertainty in EIA.
Rubinstein and Horn (1978)	Methodology for including risk analysis in EIA.
Ott (1978)	General text on environmental indices.
U.S. Army Corps of Engineers (1980)	Structured habitat approach for comparing the impacts of project alternatives.
	Note: 5 other index methods are listed in Table VII.12.

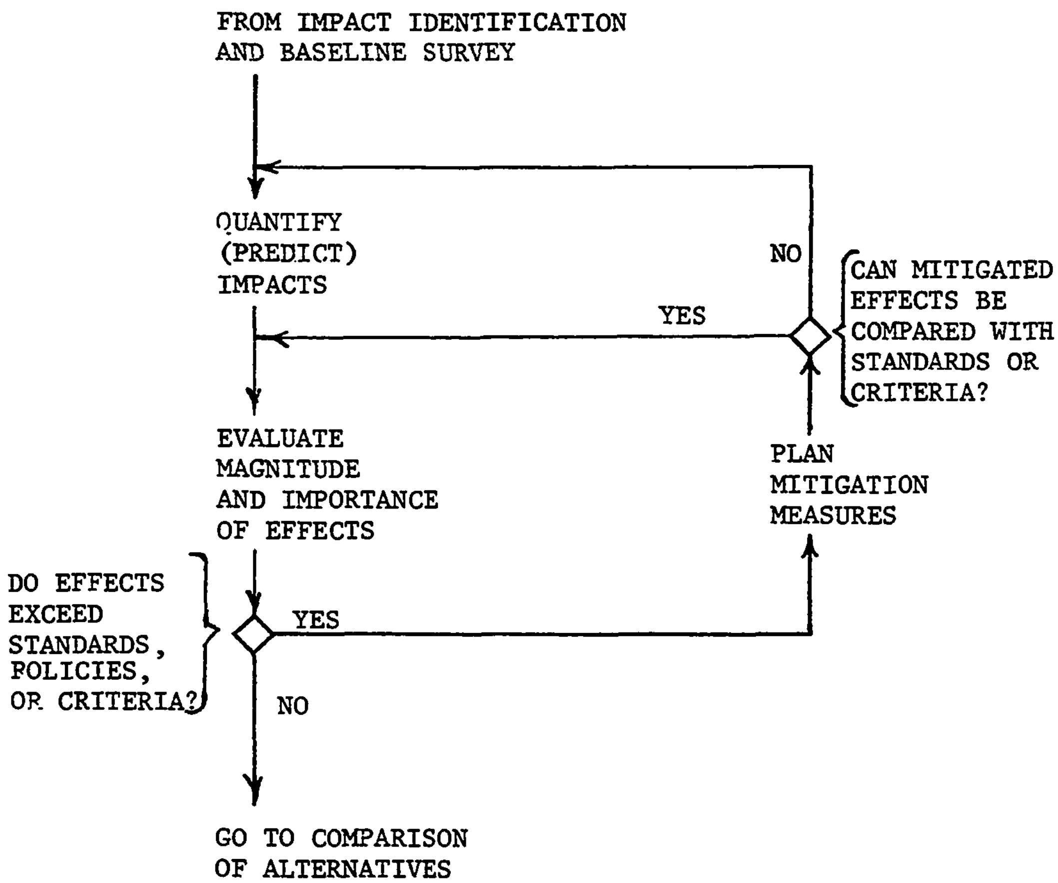
*Indicates a method which was described in this section.

any environmental study: the desire is to select the optimum alternative, not to justify a pre-determined decision.

CHAPTER VIII

PREDICTION TECHNIQUES

In this chapter, impact evaluation and mitigation planning are discussed. Although presented separately, these steps are usually done together. Also included with quantification of impacts and planning of mitigation is the need to assess the significance of impacts. The relationship between these three activities is shown in Figure VIII.1. After the identification of impacts and the baseline study, the impacts of various project alternatives are quantified. These effects are then evaluated by comparing the predicted levels with legal standards and policies for the project area, and special criteria which may have been established for the project. If all standards and criteria are satisfied, the environmental study proceeds to the comparison of alternatives. If, on the other hand, any of the criteria, policies, or standards are violated, mitigation measures must be planned. After this is done, the new impacts may be in a form that permits direct evaluation. If not, further quantification will be necessary. The new impacts are again evaluated, and the decision between mitigation planning and comparison of alternatives is again made. If, after several iterations, it is found that a particular alternative cannot meet the required standards, policies, or criteria, that alternative



FigureVIII.1:Impact Evaluation and Mitigation Planning

may be rejected. Under special circumstances, it may be forewarded to the comparison of alternatives step, with a "red-flag" clearly indicating which standards cannot be met.

The Importance of Quantification

The rating of criteria in Part 4 of the questionnaire gives some insight into the attitudes of respondents to the prediction of impacts. Two of the criteria relate directly to prediction techniques: objectivity and impact prediction. The former requires that the techniques be impersonal, objective and unbiased. The latter that they should predict the magnitude of impacts. The regional importance ratings for these two criteria are shown in Table VIII.1. The statistical analysis is contained in Appendix B.

Overall, objectivity is rated very important. No significant differences in response were found based on either level of development or geographical region. Among the responses from developing countries, no significant differences were found based upon employment or specialized environmental training. There was a tendency for third world respondents with graduate education to rate this criterion higher than those with a bachelor's degree. However, this tendency was only a weak one.

The importance attached to objectivity derives mainly from a concern that assessments should not be biased. It is generally perceived that mathematical or statistical models, or empirical techniques, are less open to changes of bias than are "expert opinion" methods. The rating of this criterion suggests that the former are

Table VIII.1: Regional Importance Ratings of Objectivity and Impact Prediction

Note: Regional average is the mean of county, state or province ratings.

Region	Regional Importance Ratings*	
	Objectivity	Impact Prediction
Developing		
Africa and Middle East	3.96	4.19
Americas	4.39	4.48
Asia and the Pacific	4.06	4.12
Europe	5.00	4.33
Industrialized		
United States	3.97	4.55
Canada	3.86	4.57
Other Industrialized	4.11	4.58

*Rating Scale: 0 = Unimportant, ignore factor; 1 = Marginally important; 2 = Moderate importance; 3 = Average importance; 4 = Very important; 5 = Extremely important.

more acceptable to environmental technologists than the latter. However, as will be seen later in this chapter, expert opinion methods are sometimes the only practical ones. In addition, most numerically based methods require some degree of professional judgment in their use.

The impact prediction criterion was rated above "very important" in all regions. There were no significant differences based on level of development or geographical region. Among responses from developing countries, there were no significant differences based on level of education, sector of employment or specialized environmental training.

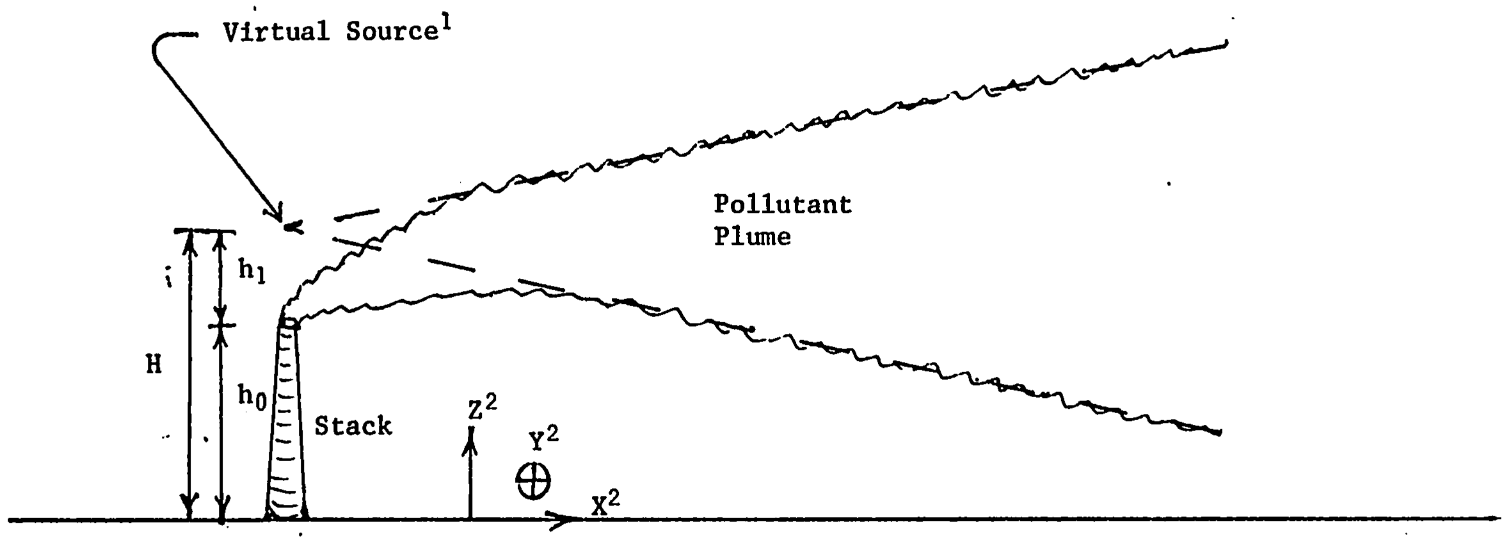
The importance of quantitative predictions relates to concerns about bias as described above. It also has to do with a concern that assessments should not be superficial. Consider the statement "the project will affect air quality by increasing carbon monoxide concentrations". This is not a basis for decision-making. In fact, the only comment it elicits is "so what?". On the other hand, consider "the project will increase carbon monoxide concentrations from existing level A to level B during inversions which occur an average of ten times per year and last an average of 6 hours each". This is a firm basis for making a decision on project implementation and mitigation planning. It is recognized that many constraints (data, hardware, manpower, and monetary resource requirements) will inhibit the production of statements of the second type. However, based on the ratings received, it would appear that quantified statements are the desirable goal.

It was previously stated that this chapter is not intended to serve as an all-inclusive list of techniques for quantifying impacts. Instead, the objective is to display a representative sample of techniques drawn from the physical-chemical, biological, cultural, and socio-economic environments. For convenience, the presentation has been divided into several headings. These are Air, Water, Other Physical-Chemical, Biological, Cultural and Socio-Economic Impacts, and Mitigation Planning.

Air Impacts

Gaussian Dispersion Model

In many industrial and other processes, air pollutants are emitted into the atmosphere. These may be from discrete point sources, such as stacks or vents, or from line or area sources. The pollutants themselves may be gaseous or particulate. The most commonly accepted means of computing the effects of gaseous and small particulate ($\leq 20\ \mu$ diameter) pollutants is the Gaussian Dispersion Model, which is applicable over short averaging times. This mathematical model assumes that the pollutant discharge disperses into the atmosphere as an expanding plume. The pollutant concentrations at any cross-section of the plume approximate a Gaussian or "normal" distribution in two dimensions. Figure VIII.2 is a general diagram for the Gaussian Dispersion Model. The basic equations from this model are as follows (Wark and Warner, 1981):



Notes: 1) The virtual source is assumed to be vertically above the emission point, at an elevation H. $H = h_0 + h_1$, where h_o = stack height if any, and h_1 = additional height due to gas velocity and temperature.

2) X is in the direction of the prevailing wind, measured from the emission source. Y is transverse to the wind direction, measured from the center-line of the plume. Z is the vertical distance, measured from ground level.

Figure VIII.2: Diagram of Gausian Dispersion Model.

a. Point Source at Ground Level:

$$C_{x,y,z} = \frac{Q}{\pi u \sigma_y \sigma_z} \exp -\tfrac{1}{2}\left[\left(\frac{y}{\sigma_y{}^2} + \frac{z}{\sigma_z{}^2}\right)\right]$$

where $C_{x,y,z}$ = concentration at point (x,y,z) ($\mu g/m^3$)

Q = emission rate ($\mu g/sec$)

u = wind speed in the x direction (m/s)

σ_y = horizontal deviation (m)

σ_z = vertical deviation (m)

y = horizontal distance from plume center-line (m)

z = vertical distance from plume center-line (m)

and notation exp(function) = $e^{(function)}$.

Directly downwind of the ground level point source, at ground level,

$$C_{x,o,o} = \frac{Q}{\Pi u \sigma_y \sigma_z}$$

b. Elevated Point Source:

$$C(x,y,z) = \frac{Q}{2\pi u \sigma_y \sigma_z} \exp\left[-\tfrac{1}{2}\left\{\frac{y^2}{\sigma_y{}^2} + \frac{(z - H)^2}{\sigma_z{}^2}\right\}\right]$$

If there is "reflection" of pollutant when the plume touches the ground, the equation becomes:

$$C(x,y,z) = \frac{Q}{2\pi u \sigma_y \sigma_z} \left[\exp -\tfrac{1}{2}\left(\frac{-y^2}{2\sigma_y{}^2}\right)\right] \left[\exp\left\{\frac{-(z - H)^2}{2\sigma_z{}^2}\right\} + \exp\left\{\frac{-(z - H)^2}{2\sigma_z{}^2}\right\}\right]$$

c. Line Source:

Examples of line sources include heavy traffic along a stretch of highway, a row of industries along a river or waterfront, and other arrangements which can be modeled as a continuously emitting infinite line source. If the wind direction is perpendicular to the line,

$$C(x,o) = \frac{2q}{(2\pi)^{\frac{1}{2}} \sigma_z u} \exp\left[-\tfrac{1}{2}\left(\frac{H}{\sigma_z}\right)^2\right]$$

where q = specific emission rate ($\mu g/s \cdot m$)

If the wind direction is not perpendicular to the line, the above equation should be divided by 6ϕ, where ϕ = angle between wind direction and line. However, this correction should not be used for $\phi < 45^o$.

Emission Factors

In order to apply any of the above formulae, it is necessary to calculate the rate at which pollutants are being or will be emitted. This is done most commonly by using emission factors. These are standard emission rates which can be applied to a number of processes (see Table VIII.2). The rate of pollutant emission may be expressed as a function of many different parameters. For example, the particulates released to the air when soil is tilled is calculated as pounds per acre per year. Incineration products are expressed in pounds per ton burned. Automobile emissions factors have units of grams per mile driven.

Emission factors are available for a host of other industrial and domestic processes. Where these factors are not available in standard tables, they can be determined from field measurements, calculated from first principles, or estimated using known emissions from similar sources. The first two approaches may be costly and time-consuming. Field measurements may be impractical if the process being considered is a new one. Calculation from first principles requires a knowledge of process chemistry as well as process efficiency. Estimation based on a known source will be reliable only if the existing discharge is representative of the proposed one.

Table VIII.2: Examples of Air Pollution Emission Factors (Hesketh, 1974, Wark and Warner, 1981).

Process	Pollutant	Quantity	Units
Agriculture:			
Soil Tilling	particulates	1,000	lb/acre-year
Fertilizers	particulates	60	lb/ton applied
Industry:			
Wood Working	particulates	5	lb/ton of wood processed
Sugar Refining	particulates	4	lb/ton of sugar produced
Kraft Wood Pulping	CO	70	lb/ton of pulp produced
	H_2S	10	lb/ton of pulp produced
Waste Incineration:	particulates	1 to 70	lb/ton incinerated
	SO_x	1	lb/ton incinerated
	CO	1 to 200	lb/ton incinerated
	NO_x	1 to 10	lb/ton incinerated
Transportation:			
Gasoline Automobiles	Hydrocarbons	.23 to 1.11	grams/mile
	CO	1.7 to 3.7	grams/mile
	NO_x	.63 to 1.48	grams/mile
Diesel Automobiles	Hydrocarbons	.16 to .47	grams/mile
	CO	.79 to 2.0	grams/mile
	NO_x	.70 to 1.72	grams/mile

The data from emission factor calculations can be used in one of two ways. If the air quality standards are based upon allowable emissions, then a direct comparison between what is expected and what is permitted can be made. Alternately, the data can be applied into a model to determine the effects of the project upon ambient air quality.

Statistical Models

The basic Gaussian models are fairly easy to apply when emission sources are few or far between. However, if many sources affect the air quality in a relatively confined area, and especially if these are non-point sources, the Gaussian models cannot be applied. If sufficient records have been kept, though, it may be possible to develop a statistical model. An example is the model developed to predict carbon monoxide concentrations in El Paso, Texas (Hubert, 1982). This is a 20-term quadratic equation which relates the arithmetic monthly mean carbon monoxide concentration to wind speed, temperature, traffic, mixing height and wind transport. Models of this type can only be developed if sufficient and appropriate data is available. In the example quoted, the data base compiled spanned eight years and came from five different sources. It is infeasible to handle this volume of data without the use of a computer.

Applications

The preceeding paragraphs have dealt with the Gaussian Dispersion Model (a mathematical model), emission factors and a statistical model. It must be stressed that these are just a few examples, presented for illustration only. There are several other techniques for predicting the effects of impacts on the air environment. These include, but are not limited to, the eddy diffusion model, a mathematical model of the diffusion of gaseous pollutants in the atmosphere; mathematical equations for the settling of particulate matter; and models accounting for chemical reactions in the production of photochemical smog.

The prediction of air impacts is important in both industrialized and developing countries. It is particularly important when the proposed development is adjacent to a population center, or where the geography or meteorology of the project site would tend to retard dispersion of pollutants.

Gaussian dispersion models are useful in industrial development projects, and when planning highways. The input data required are emission rates and wind speed. Both of these will be available in many developing countries. Many manufacturers now provide emission rates for the machinery that they build, and most countries have a meteorological department.

Statistical models can be used to predict the impacts of new industry, urban expansion or land use changes. They can also be used to plan air quality management strategies by simulating the effects of changes in various parameters. The major drawback is the need for extensive historical data, as well as computers. Both of these requirements will pose a problem in many third world countries. Fortunately, air pollution is less pressing a problem in developing areas than in industrialized ones (there are exceptions). If a carefully planned monitoring program is started now in critical areas, the required data may be available by the time that it is needed.

Water Impacts

The effects of pollutant discharges into lakes, rivers and the sea is one of the most thoroughly researched areas in the field of environmental science. The study of water pollution control and water management was started long before the present era of environmental concern. The reasons for this are simple. First, the importance of water to man's survival was recognized very early in the history of civilization. Secondly, the effects of pollution of surface waters, such as dead fish, are highly visible.

One of the most commonly used measures of water pollution is the Biochemical Oxygen Demand (BOD). This is defined as the oxygen required by bacteria to decompose the organic matter in a sample over a 5-day period at 20°C. Other indicators of pollution may be grouped into physical, inorganic chemical and biological categories. Physical parameters include color, odor, temperature and solids (suspended or dissolved). Some inorganic chemical parameters are salinity, heavy metals, phosphorus and nitrogen (ammonia, nitrites and nitrates). Biological parameters include viruses, coliforms and specific pathogens. If the level of a given indicator in both the pollutant discharge and the receiving stream are known, it is usually possible to compute the effect of that discharge on the stream. The following paragraphs contain summaries of some of the techniques for doing this.

Emission Factors

As with the emission of air pollutants, the emission of water pollutants is frequently quantified using emission factors. These factors can be applied to both point sources, such as factories, treatment plants and marine outfalls, and non-point sources, such as fertilizers applied to farmland and urban stormwater runoff. Table VIII.3 gives some examples of water pollution emission factors from non-point sources. In addition to factors of the type listed, factors for point sources are also available. These would relate, for example, to industrial operations. Emissions from wastewater treatment plants can be computed from the volume and quality of incoming sewage and the treatment efficiency.

One common practice in the calculation of total emissions is the conversion to population equivalents. This is done, for instance, when wastewater treatment plants are being designed to handle both domestic and industrial wastes. The industrial discharges would be converted using the equation

$$\text{Population Equivalent} = A \times B\ (8.34/0.17),$$

where A = industrial waste flow rate (mgd),

B = industrial waste BOD (mg/l),

8.34 = number of lb/gal, and

0.17 = number of lb BOD/person/day (Canter, 1977).

The domestic and industrial wastes can then be summed on a common basis.

Table VIII.3: Examples of Water Pollution Emission Factors (Besselievre, 1969, Canter, 1977, Velz, 1970).

Source	Pollutant	Quantity	Units
Cattle Feedlots	BOD	.56 to 1.59	lb/day/animal
	Total Solids	2 to 10	lb/day/animal
Agriculture	Nitrogen (to surface water)	2 to 28	lb/acre/year
	Nitrogen (to ground water)	38 to 166	lb/acre/year
	Soil Erosion	4800	tons/sq. mile/year
Domestic Sewage	BOD	.24 to .5	lb/person/day
	Coliform Bacteria	200 Billion	Number/person/day
Urban Runoff	BOD	6 to 14	lb/acre/year
	Nitrogen	.6 to 2.4	lb/acre/year
	Phosphorus	.2 to 1.3	lb/acre/year

The Oxygen Sag Equation

When a biological waste is introduced into a receiving stream, two opposing processes affect the dissolved oxygen (DO) level in the water. The first is deoxygenation. This occurs as the waste is decomposed by aerobic bacteria. The second process is reaeration as the stream absorbs oxygen from the atmosphere in an attempt to return to saturation. The net effect is generally a drop in DO followed by a gradual increase back to saturation level. This is called the oxygen sag curve, and is modeled at steady state by the equation:

$$D = \frac{k_1 L_a}{k_2 - k_1} \quad 10^{-k_1 t} - 10^{-k_2 t} \quad + D_a 10^{-k_2 t}$$

where D = the oxygen deficit (saturation - actual level) at time t,

L_a = BOD at start of curve after initial mixing in stream,

D_a = oxygen deficit at start of curve,

k_1 = rate of deoxygenation, and

k_2 = rate of reaeration (Nemerow, 1974).

The coefficient k_1 varies with temperature, and k_2 varies with water depth, turbulence of flow and other stream characteristics. Standard tables for k_2 are available, and k_1 is corrected using the equation

$$k_1'/k_1 = \theta^{(T'-T)}$$

where k_1', k_1 are reaction rates at temperatures T', T, respectively, and $\theta = 1.047$.

Using the sag equation, it is possible to compute the oxygen deficit at points along a stream, and the maximum deficit which results from a specific pollutant discharge. Velz (1970) has developed an "accounting" technique which permits calculation of the DO profile along a stream receiving multiple discharges. This method treats reaeration as "income" and deoxygenation as "expenditure", and is analogous to a financial cash-flow statement. Modifications of the basic equations are available to compute the oxygen sag curve for estuaries (Velz, 1970; Nemerow, 1974).

Heat Dissipation

There are several models for predicting heat loss from streams. The one developed by Le Bosquet (quoted by Velz, 1970) is similar in form to the microbial die-off equation (Chick's Law) which will be discussed later. Le Bosquet's empirical equation states:

$$\log (T_1/T_0) = - 0.434\ Kt$$

where T_0 = initial temperature differential between water and the air above it,

T_1 = temperature differential after time t, and

K = is a constant specific to the stream being studied.

The major limitation of this approach is the fact that K must be experimentally determined for each stream being studied. The parameter actually computed from field measurements is U, the heat loss coefficient. This is related to K by the equation:

$$K = \frac{0.434\ UA}{G}$$

where A = surface area of the stream reach (sq. ft.),

G = weight of water in the stream reach (lbs), and

U = has units of Btu/hr - ft^2 - ^oF.

The value of U ranges from 6 to 18 Btu/hr - ft^2 - ^{o}F. This empirical equation is useful where approximate results are adequate. If more exact predictions are required, alternative techniques like the Energy Budget Formulation (Velz, 1970) are available.

Ground Water Flow Models

The three prediction techniques just discussed all relate to the effects of pollution on surface waters. Less obvious, but no less important, are impacts on ground water. One of the basic equations applied to ground water was developed by Darcy in 1856. This law models the movement of water through a porous medium, and is valid for ground water flow in the saturated zone. Darcy's Law states:

$$Q = KA\ (\Delta h/L)$$

where Q = flow rate,

K = hydraulic conductivity,

A = cross-sectional area, and

$\Delta h/L$ = hydraulic gradient.

This basic law has been modified to compute the drawdown of the ground water table around pumping wells. Equations have been developed to calculate the drawdown in unconfined aquifers and confined aquifers, for level and sloping water tables, and for various boundary conditions. These calculations are necessary to ensure that wells installed for water supply do not exceed the safe yield. The effects of exceeding the safe yield (overpumping) may be drying up of adjacent, aquifer-fed streams and ponds or intrusion by saline water in coastal areas (Linsley and Franzini, 1972).

Mathematical Models

Mathematical models have been used to simulate contaminant transport in ground water, lakes and the marine environment. The requirements for their application are similar to those discussed under air pollution statistical models. These are a knowledge of the flow characteristics of the aquifer or water body, a knowledge of dispersion characteristics, and a suitable base of relevant data to calibrate the model. In many cases, the calculations involved in setting up the model are so complex that they are only practical with the aid of a computer. Examples of mathematical models of contaminant transport in ground water include a finite element model by Cabera and Marino (1976), a digital model by Pinder (1970), and a computer model by Konikow and Bredehoeft (1978). The National Center for Ground Water Research has prepared a summary of ground water models developed in the United States (Knox and Canter, 1980). The articles reviewed for this summary are grouped into five categories: General Status of Modeling, Flow Models, Mass Transport Models, Infiltration, Recharge and Leachates and Heat Transport Models. Table VIII.4 lists the number of models identified under each heading.

Applications

The prediction techniques described in this section are only a few of the large number of equations and models that have been developed to simulate the water environment. As populations grow and demand increases, the need to conserve sources of water becomes much greater. In this, developing nations would do well to avoid the mistakes of

Table VIII.4: Ground Water Models in the United States. (Knox and Canter, 1980).

Category	References
General Status of Modelling	12
Flow Models	
(1) Model Development	15
(2) Applications	27
Mass Transport Models	
(1) Model Development	27
(2) Applications - General	12
(3) Applications - Salt Water Intrusion	24
(4) Applications - Injection Wells	13
(5) Applications - Radioactive Material	7
Infiltration, Recharge and Leachates	
(1) Artificial Recharge	15
(2) Solute Transport	4
(3) Inigation	8
(4) Land Application	8
(5) Landfills	2
Heat Transport Models	4

their industrialized counterparts. Restoring a polluted supply is at best expensive, and at worst impossible.

Emission factors and the oxygen sag curve can be used to predict the impacts of urban development, industrialization and agriculture on surface waters. The required input data is available in most developing countries. In fact, this equation is a familiar one in engineering design offices all over the world.

Heat dissipation occurs whenever heated water is discharged into a river, lake, or sea. Power plants and some industries are among the facilities which routinely discharge hot water. The impacts of this type of project can be predicted using a heat dissipation equation like the one quoted in this section. In some developing countries, field measurements may be required to collect the input data.

Ground water flow models can be used when an aquifer is to be pumped for the first time, or when an increased rate of draw-off is proposed. Field tests may be necessary to measure existing water levels and aquifer permeability.

Mathematical models can be used to predict the impacts of pollution from surface impoundments, harbors and marinas, and off-shore installations. As with statistical air pollution models, their use in the third world will be retarded by the lack of input data and the unavailability of computers. However, there should be planning at the present time to ensure that important future needs can be met.

Other Physical-Chemical Impacts

Noise

The prediction of simple noise impacts involves three steps. The first is identification of noise sources and their levels. The second step is the calculation of the noise contribution from each source to the point of interest. The final step involves determining the cumulative effect of all contributions (Lipscomb and Taylor, 1978).

A noise emissions inventory can be drawn up for each project alternative. This inventory is a listing of all noise sources due to project activities, as well as the background noise level at the site. Noise will come from either point or line sources. Standard tables showing the noise levels emitted from various sources are available. Typical values are shown in Table VIII.5.

Two models are available for computing sound levels at a given point. For point sources, the Inverse Square law states:

$$SL1 - SL2 = 20 \log_{10} (r_2/r_1)$$

where SL1 and SL2 are the sound levels at points 1 and 2 respectively, and r_1 and r_2 are the distances from the source to points 1 and 2.

For line sources, such as roads, railways, etc., the equation becomes

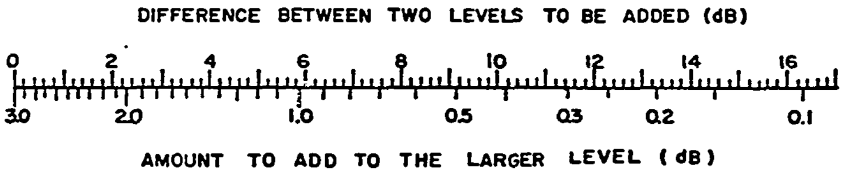
$$SL1 - SL2 = 10 \log_{10} (r_2/r_1)$$

For a point source, the sound level decreases by 6 dBA as the distance from the source is doubled. The decrease due to doubling of distance is 3 dBA for line sources.

When the contributions from different sources have been determined, these levels must be added together. Figure VIII.3

Table VIII.5: Sound Levels from Representative Sources (Lipscomb and Taylor, 1978).

Source	Distance of Measurement	Noise Level (dBA)
Rocket Engine	(Nearby)	180
Jet Takeoff	(Nearby)	150
Jet Takeoff	60 m	120
Rock Concert	2 m	120
General Construction	3 m	110
Heavy Truck	15 m	90



Nomograph for Adding Sound Levels
(Lipscomb and Taylor, 1978)

Example: Four sources contribute 82.5, 83, 84.8 and 77.7 dB to a point. What is the resulting sound level?

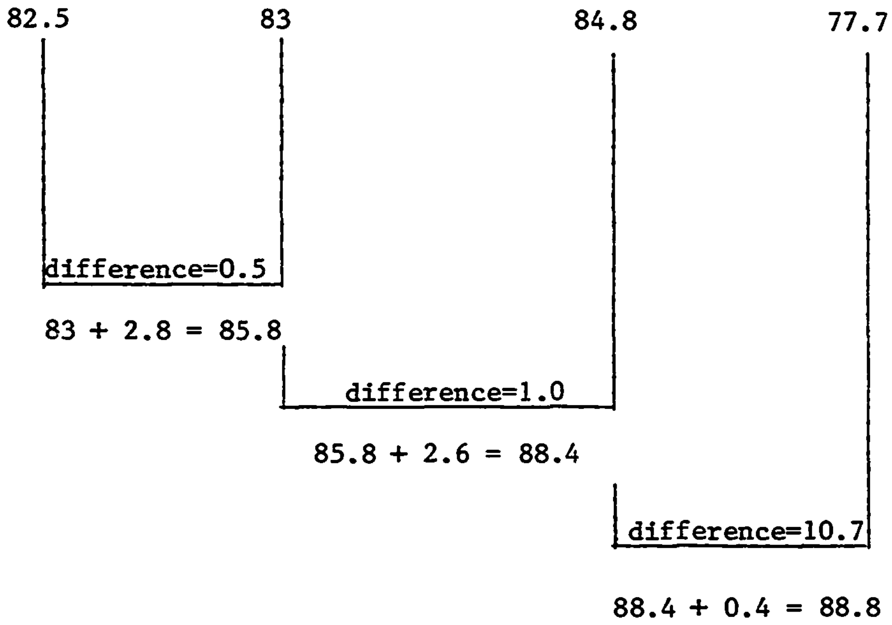


Figure VIII.3: Summation of Sound Levels presents a nomograph which is used to sum sound levels, and an example of the step-wise approach to computing the result of multiple contributions.

When a large number of sources are present, a computer would facilitate the calculation of sound levels around a project. These can be used to draw sound level contours which would indicate areas where standards or criteria will be violated by specific project alternatives. Such computer analyses have been applied to highway and airport projects.

Erosion of Soil

A good technique for predicting the loss of soils due to erosion by runoff is the Universal Soil Loss Equation (Wischmeier and Smith, 1961). The mass of soil moved is computed as the product of five factors:

$$A = RKLSC$$

where A = soil lost per unit area per unit time, usually tons/acre/year;

R = rainfall energy factor, based on 2-year, 6-hour maximum rainfall amount;

K = soil erodibility factor, based on soil type and characteristics;

L = length water travels along slope;

S = degree of slope; and

C = cover factor, based on vegetation and litter on slope.

This equation deals with the amounts of soil that are disturbed and moved from one point to another. In some cases, the movement may only be a few feet. Thus, the computed soil loss is a good indicator of landscape stability. However, it does not represent the actual volume of soil that is washed into the surface water system of streams and lakes. This volume of sediment entering surface water can be computed by multiplying the soil loss value from the universal soil loss equation by an appropriate sediment delivery factor.

Radioactive Material

Radioactive material is released into the environment either in planned, limited discharges or by accident. When these releases are into water, a dynamic equilibrium is established between the concentration in the water and the concentration in the bottom sediments. In order to realistically predict radionuclide buildup in the environment and exposure levels to man and the biota, a model has been developed to predict transfer between the receiving water and bottom sediments (Miller and Stannard, 1976).

Figure VIII.4 is a diagram of the model. The receiving environment is composed of four elements: receiving water; exchangable bottom sediments; interstitial water; and non-exchangable bottom sediments. The radioactive material enters the system when contaminated liquid effluent is discharged into the receiving water (X_1). From here, some is lost due to outflow from the system and radioactive decay. Of the remainder, part remains in X_1 while the rest is transfered across the water/sediment interface into the interstitial water (X_2) and the exchangable bottom sediment (X_3). Of the radionuclides entering X_2, part is retained, part is lost by radioactive decay and to deeper sediments, some goes back to X_1, and

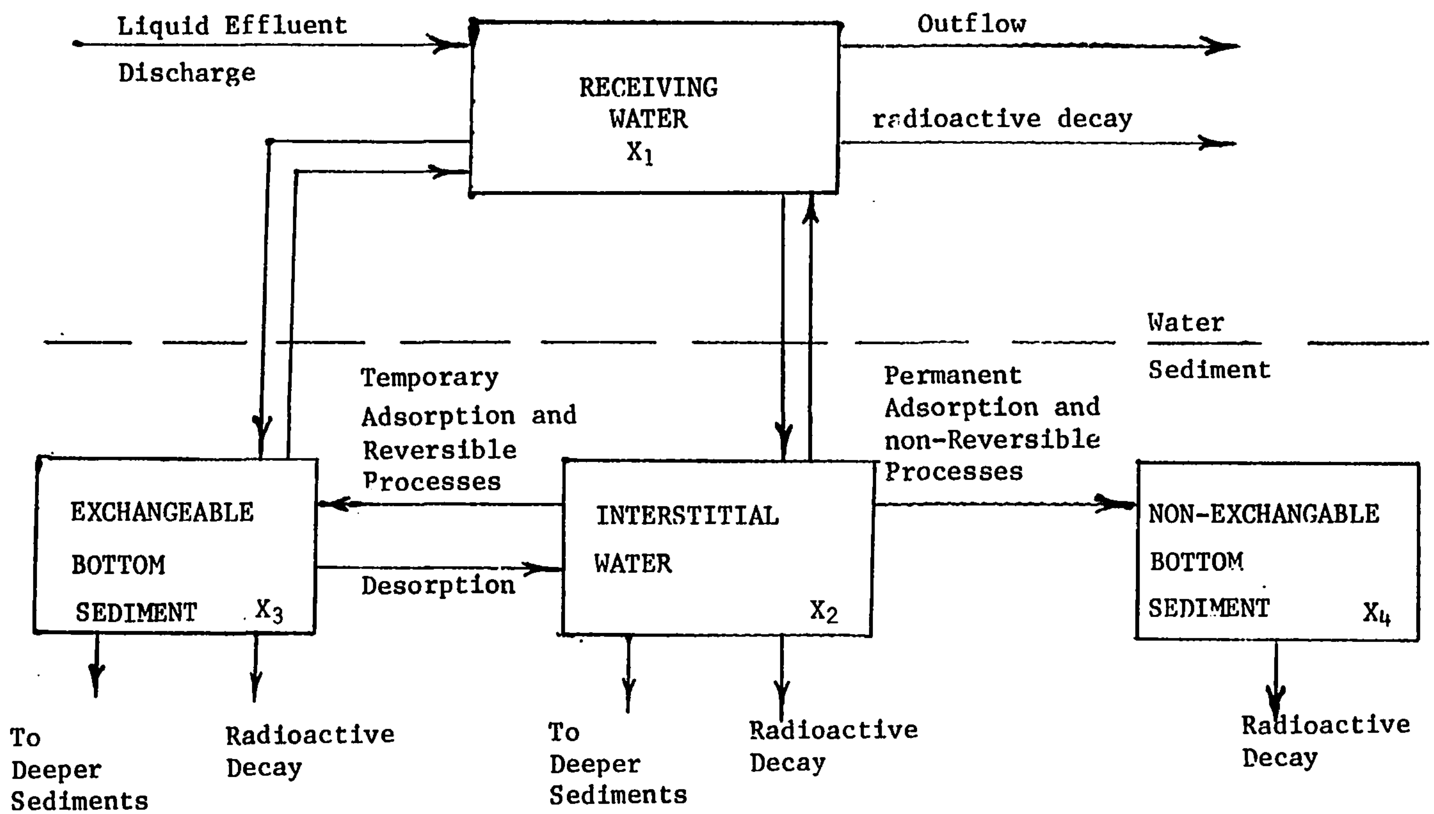


Figure VIII.4: Diagram of Radionuclide Transfer Model.
(Miller and Stannard, 1976)

the rest is transferred to the bottom sediments (X_3 and X_4). The radionuclides which are attached to bottom sediments by permanent adsorption or non-reversible reactions are considered to have entered the non-exchangable bottom sediment (X_4). From here, the only loss is by radioactive decay. The radionuclides which adhere to the bottom sediment by reversible processes are considered to have entered the exchangable bottom sediment (X_3). From this element, some are released back to X_1 and X_2, part is lost to radioactive decay and deeper sediments, and the remainder is retained.

The system shown in Figure VIII.4 is modeled using a series of differential equations. The solution to these equations yields two factors. One is used to compute the radionuclide concentration in the receiving water. The other is used to predict concentration in the bottom sediments. In the referenced article (Miller and Stannard, 1976) an example of the application of the model is presented. Models of this type are not limited to radionuclide transport. More generally, they can be used to simulate the phenomenon of chemical cycling in the environment.

Applications

This section has touched on just three of the many techniques for modeling impacts on other aspects of the physical-chemical environment. Obviously, a comprehensive review of such models is beyond the scope of this dissertation. Noise modeling is necessary on transport (highway and airport) projects, industrial developments and urban expansions. In addition to the long-term impacts, noise is a short-term impact of almost all construction. Soil erosion results from changes in ground cover, and is also a short-term impact of construction. It can also be a long-term result of projects which require land use changes, such as felling of forests to create cropland. The cycling of radionuclides or other chemicals must be considered when these materials are discharged as the waste products of industry. The first two prediction techniques require inputs that would probably be available in many developing countries. The third requires an understanding of the exchange processes involved, as well as data to calibrate the model. These inputs may not be readily available in parts of the third world.

Biological Impacts

Microbial Die-off

The rate at which microbes die in an unfavorable environment is modeled by Chick's Law. This states that a given percentage of the remaining microbial population dies in each successive time period. Formulated as an equation, Chick's Law is:

$$\log (B/B_0) = -kt$$

where B_0 = initial number of bacteria,

B = number of bacteria after time t, and

k = death rate (ranging from 0.5 to 0.9 in warm weather and from 0.26 to 0.46 in cool weather for rivers).

If B is plotted against t on semilog paper, the die-off curve becomes a down-ward sloping straight line. This is a convenient format, since it allows integration of a series of discharges into a stream. This is shown on Figure VIII.5 (Velz, 1970). A population equivalent (PE) of 10,000 is introduced at discharge 1. Die-off proceeds at the rate shown, and only 500 PE remains at discharge 2. Here, an additional 11,500 PE is introduced, bringing the total 12,000 PE. Die-off reduces the number to 1,000 PE at discharge 3, where 9,000 PE are added. This brings the total back to 10,000 PE, and die-off reduces the number to just over 1,000 at the end of the graph.

Compartmental Approach to Modeling

This approach is typically used to model the gross dynamics of whole ecosystems. It has been used to model energy flow, nutrient cycling and mass flow. The ecosystem is divided into "pools" (of energy, nutrient, etc.), and arrows are used to indicate flow between pools (Odum, 1971). Figure VIII.6 is the schematic of a model of biomass change in a grassland ecosystem. Six pools are identified, and eight arrows indicate flow. Note that there is two-way flow between pools 2 and 3. The actual flow is quantified as a series of differential equations indicating changes within each pool over time. For example, in the cited example it was found that:

$$\Delta V_4/\Delta t = 0.002\ V_2 - 0.001\ V_4$$

where t = time, and

V_i = biomass in pool i (gm/m^2),

the constants 0.002 and 0.001 have units of ($time^{-1}$).

These models can be used to quantify the effects of changes in one pool on the other pools. The models are usually designed from theoretical principles and calibrated from actual field measurements. The model is deemed inappropriate if equations cannot be developed to "fit" the data

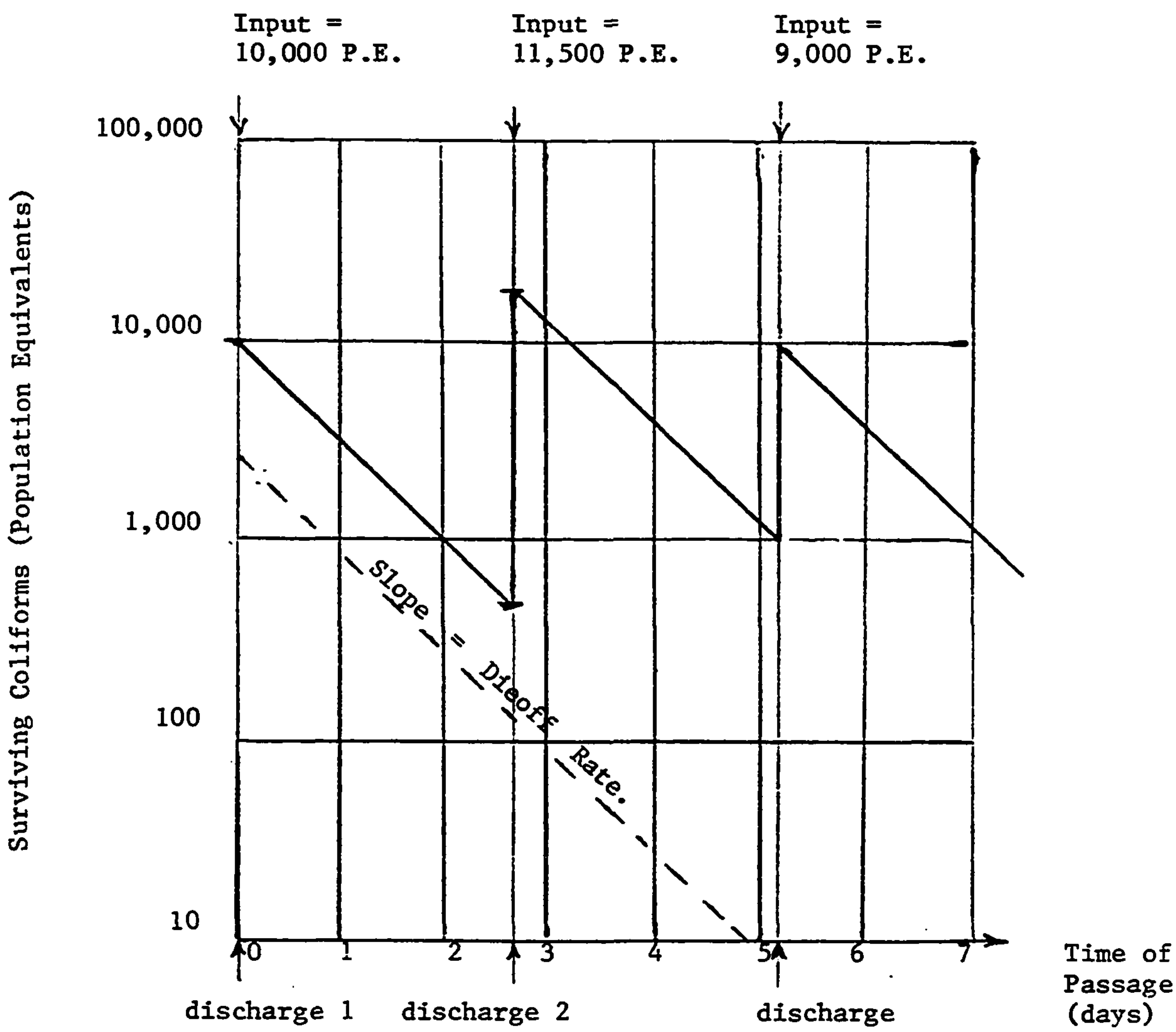


Figure VIII.5: Coliform Bacteria Surviving from Mutiple Sources. (After Velz, 1970)

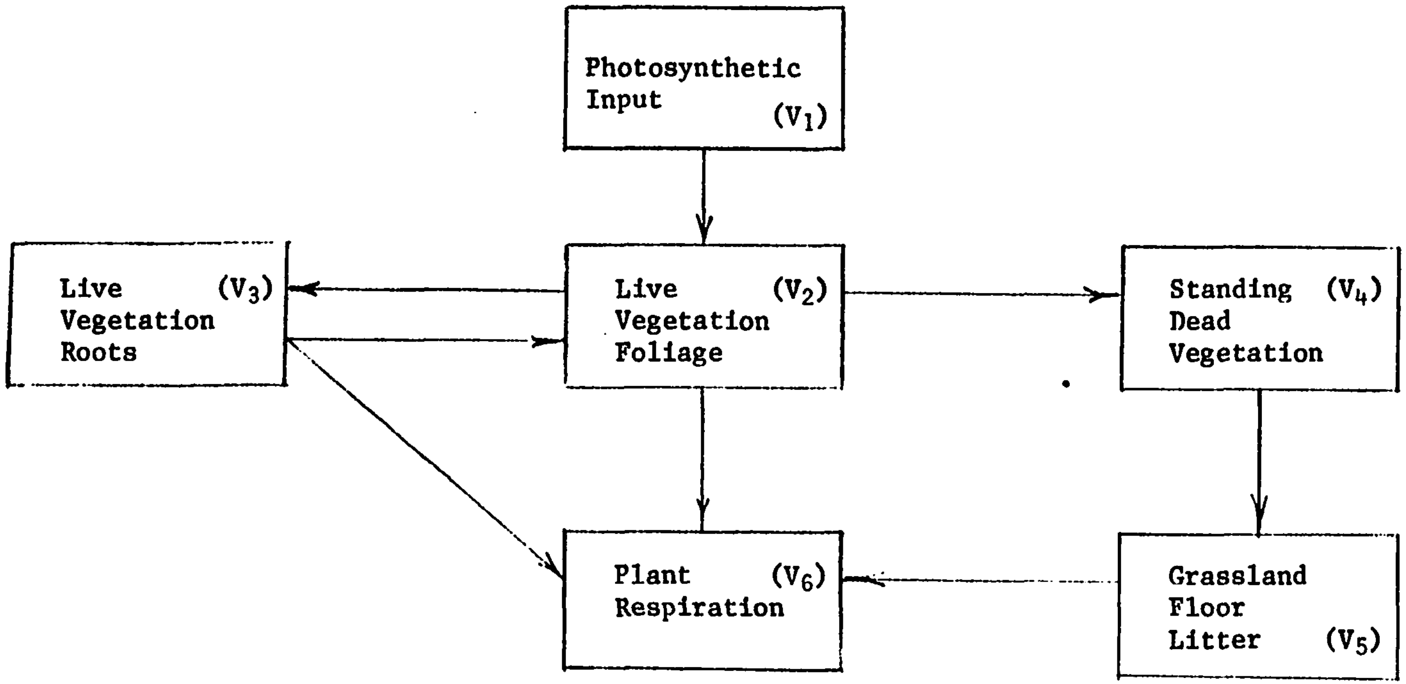


Figure VIII.6: Compartment Model of Biomass Change in a Grassland Ecosystem (Odum, 1971).

being used to calibrate it. This fact and the simplification of complex biological processes are two of the main objections raised to compartment models.

Experimental Components Approach to Modeling

A second approach to the modeling of biological phenomena consists of dividing an ecological process into very simple sub-processes or "experimental components". Each component is then represented as a mathematical equation or a set of equations. The components are then "reassembled" to form a model of the whole process. Because of the need to represent lag times, discontinuities and threshold responses, and because of the complexity of the equations involved, computers are a necessity (Odum, 1971). Experimental components models have been used to analyze several resource management problems. Another example is its application to the predator-prey relationship. Some of the sub-processes into which the overall relationship were divided were:

- hunger level and searching rate of predator,
- prey density, and
- interference between predators.

The resulting complex model was used to compute predator and prey density over time in both stable and unstable conditions.

Other Models

Odum (1971) lists several other models which cover a wide range of biological processes. These are repeated here to show the diverse aspects of the biological environment which can be modeled.

- Energy flow in a grassland ecosystem was modeled using a combined compartment/experimental components approach.

- The plant production/wildlife population relationship was modeled in order to examine land use in forest areas.

- Among the sub-processes represented by mathematical equations in the plant production/wildlife population model were: age structure, birth rates, death rates, feeding patterns, and the effect of food intake on reproduction and death.

- Electrical analog models have been developed to represent tribal farming in Africa, semi-commercial farming in India and high-production agriculture in the United States.

Applications

Three techniques for predicting biological impacts were described in this section. These were a die-off equation and two types of models. The first method may be used when designing wastewater treatment plants. The two models can be used on several types of projects. For example, they can predict the effects of increased livestock on rangeland; farming type on food production; or increased hunting on ecosystem balance. This last can result indirectly from highway projects. In terms of applicability, the input data for the simple equation methods are probably more readily available in developing countries than the inputs required for the models. As before, these three methods are just a small example of what is available.

Cultural Impacts

One of the lessons learned during the first ten years of NEPA is that there are limits to quantification (Staats, 1982). The cultural environment is one area where this truism is particularly appropriate. In attempting to predict cultural impacts, modes and mechanisms of change may be either tortuously complex or obscure or both. Thus, forecasts based on models of these modes and mechanisms are often in error. In the following paragraphs, two qualitative approaches to cultural impact prediction are described. In each case, the assumptions and limitations of the approach are stated, and the basic steps outlined. The two approaches are scenarios and expert opinion methods (Institute of Water Resources, 1975).

Scenarios

This approach is based on the assumption of surprise-free futures. The cultural environment is considered to be composed of high-inertia segments. Thus, each segment can be expected to continue in its state of rest or uniform change. In other words, what is stable will remain stable, and what is changing will continue to change at the same rate and in the same direction. It is possible to construct several scenarios of the cultural effects of a particular project alternative, as long as these assume no sudden discontinuities or revolutionary changes. Each scenario is simply an outline of one conceivable future state of affairs, given present conditions and assumed events (such as project implementation). These are descriptions of plausible futures rather than predictions of what will occur.

The basic limitations of the scenarios approach are accuracy and the scenario writer. Accuracy is limited because scenarios are used most often when underlying mechanisms are not understood. Thus, they are neither detailed, accurate nor complete if used as forecasts. The scenario writer may fall into the trap of trying to sift scenarios to determine the "real forecast". This comes from a natural tendency to accept the "best story" as a prediction of the future. However, this is not the intent of the scenario approach.

The scenario approach consists of eight steps:

(1) Identify Users and Uses

The first step consists of identifying the audience for which the scenarios are being written, and the uses to which they will be put. In the specific case of the cultural environment, users are the decision-makers for whom the study is being conducted, and potential reviewers of the study. The primary use will be to develop contingency plans for mitigation. A secondary use may be to compare project alternatives.

(2) Select a Time Horizon

The time horizon is the date to which scenarios are being projected. This is usually stipulated in advance by the study audience.

(3) Select a Territorial Scope

The territorial scope defines the physical boundaries of the scenarios. This may be defined within the scope of the overall environmental study.

(4) Select Critical Issues

Pertinent concerns, opportunities and constraints bearing on potential solutions must be identified for consideration.

(5) Select Basic Topics

The specific topics of interest must be identified. These may be recreation, community interaction, religious practices, or others.

(6) Develop a Database

Data to be used to develop scenarios must be compiled and organized. If the cultural impact assessment forms part of an environmental study, this task may become part of the overall database survey.

(7) Develop Scenarios

Using the data collected in step (6) and the principles of stability and constant change, a set of scenarios can be developed. Table VIII.6 is an example of a set of scenarios that was developed during a study of urban growth.

(8) Distribute Scenarios

Once scenarios have been developed, they are circulated first to reviewers for comment, and then to the authorities to aid in decision-making or contingency planning of mitigation measures.

Expert Opinion Methods

There are several techniques which base impact predictions on the opinion of experts in the field. Three of these are meetings, conferences/seminars and the Delphi technique. The basic principle in all cases is to ask a group of persons to come to a consensus on the effects of a given impact. It is a prerequisite of these methods that the individuals in the group be trained and experienced in the specific area being studied. This, in fact, is the major drawback in expert opinion methods: who is an expert? It has been suggested (Institute of Water Resources, 1975) that this simple question is related to three others: What is the forecast topic? Who are the sponsors? and Who are the end-users? A fourth question could be added: What method is being used?

The first question is self-explanatory. The idea is to assemble a group whose pooled knowledge will represent the state-of-the-art in the study field. The second and third questions actually

Table VIII.6: Four Scenarios for Urban Growth (Institute of Water Resources, 1975).

Scenario A:	Urban Sprawl: Uncontrolled expansion of urban area, following current land-use patterns.
Scenario B:	Spiderweb Development: As for A, except that much of the development will occur in fingerlike projections along major transportation corridors.
Scenario C:	Controlled Growth: Planned expansion, emphasizing high density residential developments and revitilization of the urban core.
Scenario D:	Satellite Cities: Similar to C, but including the development of strategically sited satellite cities around the urban area.

relate to the emphasis of the prediction. Consider, for example, a study of changes in recreational patterns associated with an artificial lake. The business community will be interested in opportunities for investment, such as recreational equipment sales and rental. The managers of the lake will want projections on which to base staff size. And the health authorities will want predictions concerning the spread of communicable diseases. The fourth question may affect the level of training required for inclusion on the panel.

Table VIII.7 is a comparison between the three expert opinion methods mentioned earlier. Meetings and conferences/seminars are face-to-face discussions of an expert group, the former being more flexible than the latter. These methods are subject to several psychological ill-effects: "noise", dominance and conformity. "Noise" refers to the many distractions which affect an average committee discussion. For example, during the course of a discussion one opinion may be repeated many times by an individual who champions it. Studies have shown that the statements which are accepted by committees are not necessarily the most relevant or important ones. Instead, they tend to be the ones which have been repeated the most often. Dominance refers to the ability of certain persons to impose their views on others. Thus, the opinion of the most senior member, or even just the loudest member, becomes the consensus. Finally, most people tend to conform to peer pressure and avoid radical-sounding positions.

The Delphi technique is an improvement upon the traditional expert opinion approaches to obtaining a consensus of opinion. Like the committee, it draws upon the knowledge of a panel of experts on the

Table VIII.7: Comparison of Three Expert Opinion Methods (Linestone and Turoff, 1975).

	Meeting	Conference or Seminar	Delphi
Effective Group Size:	Small to medium	Small to large	Small to large
Interaction mode:	Medium	Large	Large
Length of Interaction:	Medium to long	Long	Short to medium
Number of Interactions:	Varies	Single	Multiple
Format:	Flexible. Could be open or controlled by chairman.	Directed. Presentations follow pre-arranged agenda.	Structured. All interactions go through the monitor.
Costs:	Travel and individuals' time.	Travel, fees and individuals' time.	Clerical, secretarial, individuals' and monitor's time.
Other Considerations:	Equal flow of information to and from all. Psychological ill-effects maximized.	Efficient flow of information from few to many.	Equal flow of information to and from all. Psychological ill-effects minimized. Time demands minimized.

subject being investigated. Unlike the committee, the Delphi technique utilizes individual assessment, statistical analysis and controlled feedback to arrive at a consensus (Linstone and Turoff, 1975). These changes in format reduce the effects of "noise", dominance and conformity.

When a Delphi study is performed, each panelist is asked to assess the situation independently. The results are then pooled, and statistically analyzed. Each expert is then allowed to study his own responses and the pooled group response. He is asked to review his own answers in light of the group consensus. These new responses are again pooled and analyzed. If necessary, the process is taken through third and fourth rounds. The advantages are many. Since the same Delphi instrument is circulated to all panelists, the chance of bias due to variations of the questionnaire is removed. The experts work independently, and are therefore not subjected to repetition of arguments or dominance by others. The anonymity resulting from the statistical analysis removes the pressure to conform. Also, the anonymity allows the individual to change his mind without embarrassment.

Expert opinion methods in general, and the Delphi technique in particular, can be useful tools in predicting impacts upon the cultural environment. By their nature, they are subjective and non-quantitative. However, they can be tailored to give reasonable answers. The following are some pitfalls which should be avoided when using these methods (Linstone and Turoff, 1975).

1. Discounting the Future: There is a natural tendency, particularly in the Western world, to attach more importance to short-term achievements than long-term results. When the future is being predicted, this may cause an emphasis on short-term impacts while long-term changes are ignored.

2. The Prediction Urge: Simply stated, this urge replaces the statement "There is a 60% chance that X will occur" with the prediction "X will occur". Firm predictions of the latter type are usually inapplicable in an expert opinion projection.

3. The Simplification Urge: The format of many expert opinion methods tends to encourage a simplified view of rather complex processes. The danger here is oversimplification to a point of distortion.

4. Illusory Expertise: The importance of selecting an appropriate panel of experts cannot be over-emphasized. It must be recognized that "years on the job" does not equate to experience, nor does "degrees earned" translate to education.

5. Sloppy Execution: The best of projections are useless if they are not clearly and accurately communicated. The minutes of a meeting and the summary of a Delphi study are as important as the subjects they report. In this context, the writer of the minutes and the monitor of the Delphi are critical links in the study chain. Other forms of sloppiness include errors in analyzing Delphi responses and impatience by the panel to "get the job over with".

6. Optimism-Pessimism Bias: Some persons are naturally optimistic by nature, and others pessimistic. This type of bias cannot be removed, and should even itself out over a large panel. However, there are other types of optimism and pessimism. For example, students of a common teacher or employees of one firm may develop a uniformly optimistic or pessimistic approach to evaluating a particular impact. Care should be taken when choosing a panel to avoid selecting too many people with a common bias.

7. Overselling: "In their enthusiasm some analysts have urged Delphi for practically every use except cure of the common cold." This quotation by Linstone (Linstone and Turoff, 1975) can be applied to many expert opinion methods. Each method has its own objectives, applications and limitations. These must be carefully weighed when choosing a technique for use on a particular study.

8. Deception: Most expert opinion methods can be used to deceive the audience.

Applications

Two approaches to predicting cultural impacts were described in this section: scenarios and expert opinion techniques. Both of these are subjective techniques, depending upon the training and experience of "experts". Cultural impacts can result from all types of projects. Particularly severe cultural impacts have been noted on dam projects, due to relocation of villages; in housing developments, due to changes in community structure; and in industrialization, due to lifestyle changes. Cultural impacts are quite complex. Further, many large projects in developing areas are without precedent in the affected country. Therefore, subjective techniques may be the only ones that can predict cultural impacts in the third world at the present time. Because this is so, it is desirable to base predictions on structured approaches.

Socio-Economic Impacts

Regional Income Equation

This economic technique is used to calculate the net income of a region. It is based on the Export Base Theory, which has two fundamental concepts. The first is that an area's economy can be divided into two sets of economic units. One is the Basic Sector, which sells goods and services to markets outside the area. The rest of the economic units make up the Non-basic Sector, and they supply customers within the area. The second concept in the Theory is that

Non-basic activity is uniquely related to Basic activity. Thus a given change in the level of Basic activity will cause a predictable change in the level of Non-basic activity. This relationship results from the interdependence between sectors, and is termed the multiplier effect. One equation that models this relationship is:

$$Y = C + I + G + X - M - T$$

where Y = net area income,

X = area exports

M = imports

C = consumption expenditures

I = investment expenditures

G = local government expenditures, and

T = tax payments (Leistritz and Murdock, 1981).

The above equation relates to a single region. It can be used to calculate the effects of project impacts on the economic setting (as indexed by net area income) of the affected area. If sufficient data is available, it is possible to expand the single-region models into a multi-region model. Multi-region models are conceptually superior, but require an amount of background data that is hardly ever available. The single-area equation can also be used to compute K, the Export Multiplier. This is an indicator of economic "health", with more diversified and self-sufficient regional economies having a higher value of K.

Disaggregated Employment Multipliers

An equation for estimating total employment in an area has been developed (Leistritz and Murdock, 1981). The approach used was to estimate separate multipliers for each basic industry. This eliminated problems in other models that are posed by differentials in wage rates and input purchase patterns. The disaggregated model states:

$$E_t = a + b_1X_1 + b_2X_2 + b_3X_3 + u$$

where E_t = total employment,

a = intercept constant

X_1, X_2, X_3 = employment in three basic industries,

b_1, b_2, b_3 = industry-specific employment multipliers, and

u = is a stochastic disturbance term.

The "b" multipliers each indicate the change in total employment which would result from a unit change in the appropriate basic industry. They are determined using regression analysis on data from a large number of areas that have similar economic environments to the area being studied. This model can be used to determine overall employment changes resulting from project-induced changes in basic industry employment.

Population Projections

Several extrapolation techniques exist for estimating population at some future time (Leistritz and Murdock, 1981). The simplest of these use a linear growth model and two known populations in the past to predict the future population. The equation is:

$$P_2 = P_1 + \left[P_1 - P_0\right] \frac{(t_2 - t_1)}{(t_1 - t_0)}$$

where P_0, P_1, and P_2 are the populations at years t_0, t_1, and t_2. P_0 and P_1 are known.

This technique is useful for projections over short periods when birth, death and migration rates are relatively constant. Over longer periods, or when the population is being subjected to dramatic changes, it becomes inadequate.

A slightly more complicated procedure is used to acknowledge the exponential nature of population growth. This is the continuous compound interest formula, which states:

$$P_2 = P_1 e^{rt}$$

where P_1, P_2 are as before, with P_1 known,

t = length of time between P_1 and P_2, and

r = rate of growth per unit time.

The value of r is computed from known populations P_0 and P_1, measured t years apart.

$$r = (1/t) \log (P_1/P_0)$$

where log = natural logorithm

The exponential technique is superior to linear extrapolation, and can be applied to longer time periods. However, it is still limited to areas and times of relative socio-economic stability.

One method of including other variables into the computation is the use of multiple regression. The multiple linear regression equation has the form:

$$P = a + b_1X_1 + b_2X_2 + \ldots + b_nX_n$$

where P = population,

$X_1, \ldots X_n$ = independent variables, such as income, birth rate, death rate, population density, etc.

$b_1, \ldots b_n$ = slope or amount of change in P per unit change in X, and

a = intercept value.

Multiple regression allows the input of many independent variables. It can therefore be used to predict populations even in times of social and economic change. The equation above relates to multiple linear regression. However, the regression technique can be expanded to include logarithmic, exponential, quadratic and other relationships. The basic drawback of this method is the relatively large data-base required to compute the a and b values.

Gravity Technique for Settlement Patterns

This technique is used to estimate the distribution of project workers into the surrounding communities. The premise upon which it is based is that larger and nearer communities will gain more population from a project than further and smaller ones.

$$W_{ij} = \frac{(P_{ij}/D_{ij})}{\sum_{\text{all } i} (P_i/D_{ij})}$$

where W_{ij} = the proportion of the incoming work force at project j who will settle at community i,

D_{ij} = distance from project j to community i, and

P_i = the population of community i.

This equation is predictive rather than explanatory. However, experience shows that its results are generally valid. It is more successful in predicting settlement in urban areas than in rural areas (Leistritz and Murdock, 1981).

Computerized Models

The prediction of social and economic impacts often requires a large number of complex calculations, involving a great amount of data.

To be useful, these calculations must be accurate, and the results presented to decision-makers in a timely fashion. To achieve this combination of accuracy and speed, computerized models have been developed. A comparison of 13 such models is shown on Table VIII.8 (Leistritz and Murdock, 1981).

One obvious impediment to the use of computerized models in the third world is the unavailability of computers, programmers and input data. At the present, therefore, the use of these models will not be possible in some developing countries. However, it is probable that such techniques will become more widespread in the future, as the necessary equipment and expertise becomes available.

Applications

In this section, four predictive equations were described, and thirteen computerized models were listed. As before, these are only a few examples of the many techniques available for quantifying socio-economic impacts. The equations are designed to predict impacts upon regional income, employment, population and settlement patterns. Each of these is an important consideration in developing areas. Projects which may affect regional income and employment are new industries or a change in agricultural crop. Population may also be affected by new industries. In addition, the provision of electricity, water and health care can alter population by slowing migration out of an area. The equation for estimating the settlement of distribution of construction workers is very useful in quantifying the short-term impacts on housing.

Table VIII.8: Comparison of 13 Socio-Economic Computerized Models (Leistritz and Murdock, 1981).

Model	Dimensions Included						Project Phases Analyzed		
	Economic	Demographic	Interface	Distribution	Public Service	Fiscal	Baseline	Construction	Operational
ATOM-3	X	X[1]	X				X	X	X
BOOM-1	X	X	X		X	X[2]	X	X	X
BREAM	X	X	X	X			X	X	X
CUPS	X	X	X	X		X[3]	X	X	X
CPEIO	X	X	X		X[4]		X	X	X
HARC	X	X[1]	X	X	X		X	X	X
MULTIREGION	X	X	X	X			X	X	X
NAVAHO	X	X	X	X			X	X	X
NEW MEXICO	X	X	X				X	X	X
RED	X	X	X	X	X	X	X	X	X
SEAM	X	X	X	X	X	X[3]	X	X	X
SIMPACT	X	X	X	X	X	X	X	X	X
WEST	X	X		X	X[4]	X	X	X	X

[1] Includes population submodules

[2] Costs are aggregated

[3] Revenues not calculated

[4] Only two services projected.

Computerized socio-economic models are probably not directly applicable in the third world at the present time. As with statistical air quality models and mathematical water quality models, the reasons are a lack of input data and the unavailability of computers. However, as data is gathered and hardware becomes available, such models will become more frequently used in developing countries.

Mitigation Planning

It was previously shown in Figure VIII.1 that mitigation planning becomes necessary when the effects of a project alternative would violate an existing environmental quality standard or policy or a project-specific environmental criterion. There are three approaches to mitigation planning: engineering measures; management measures; and policy revision. The first two are traditional approaches that have been used on many projects in the past. They are both based on the concept that steps can be taken to reduce adverse project effects so that standards, policies, and criteria can be met. Policy revision is a somewhat different approach to complying with standards, and can be very controversial. The basic concept is a close scrutiny of the standard which would be violated, in order to determine whether a specific exemption can be granted for the project. A fuller discussion of each of these approaches follows, and examples of each type of measure are presented. As in the previous section on impact evaluation, the intent here is not to compile a complete list of possible mitigation measures. Instead, the examples presented are meant to illustrate the diversity of measures which are available.

Engineering Measures

Traditionally, engineering measures have been the most common approach to mitigating project impacts. These involve waste treatment or the use of alternate equipment and material in order to improve the effluent that is discharged into the environment. Thus, this approach has been considered more a part of engineering design than environmental impact assessment. In fact, it straddles both areas. Technologists studying the environmental impacts of a project can give valuable inputs into the choice of measures. On the other hand, it is the designer who will be responsible for including these measures in the overall project.

Table VIII.9 lists examples of engineering measures for impact mitigation. Impacts on the air and water environment can be controlled by upgrading the waste effluent prior to discharge. The treatment process will be dictated by the contaminants contained in the effluent stream, as well as the capacity of the environment to accept these pollutants. Most effluent streams will contain several contaminants, and may thus need several forms of treatment. It is important to note that treatment of waste effluent requires collection of the effluent. For this reason, effluents from point sources are easier to treat than those from dispersed sources, because they are easier to collect.

Noise impacts can be reduced by the use of mufflers on individual pieces of equipment, sound barriers around operating areas, or by changing the basic process. Examples of this type of noise mitigation are mufflers on compressors and other construction equipment. Sound barriers include acoustic walls, floors and ceilings,

Table VIII.9: Engineering Measures for Impact Mitigation

Impact	Mitigation Measures
AIR ENVIRONMENT	
1. Particulates	Cyclones, baghouse filters, settling chambers, inertial seperators and electrostatic precipitators
2. Gases	Scrubbing towers and adsorbers
WATER ENVIRONMENT	
1. Organics	Oxidation ponds, trickling filters, activated sludge and extended aeration
2. Grease	Grease traps
3. Settable Solids	Settling tanks
4. Suspended Solids	Gravity filtration, upflow filtration
5. Inorganics (including metals)	Adsorption
6. Thermal	Cooling towers or cooling ponds
OTHER PHYSICAL ENVIRONMENT	
1. Noise	Mufflers, sound barriers or process changes
2. Soil Erosion	Slope protection by regrading, plantings, etc.
BIOLOGICAL ENVIRONMENT	
1. Migration Route Obstruction	Fish Ladders around dams, underpasses below highways
2. Loss of Recreational Areas	Provide replacement areas
SOCIO-ECONOMIC ENVIRONMENT	
1. Housing Needs of Construction Workers	Construct temporary work camps
2. Strain on existing services	Increase capacity of utilities, schools, police, fire department, etc.

and vegetative barriers around open areas. Process modification involves, for example, the use of crushers instead of hammermills in concrete aggregate production, or the use of electrical motors instead of diesel engines in forklifts in a warehouse. The basic concept is to do the required task using quieter methods.

Soil erosion can be reduced by regrading the site to flatten slopes. Another method is the use of grass, shrubs and other vegetation to stabilize slopes. The use of vegetation also reduces the force with which raindrops strike the ground, thus further reducing erosion. In areas subject to heavy erosion, such as gullies, rock protection or chemically stabilized soil may be necessary.

The examples of impacts to the biological environment cited in Table VIII.9 are obstruction of migration routes and destruction of nesting sites. The former can be mitigated by artificial structures which by-pass the obstruction. Fish ladders can be built around dams or rivers, and underpasses below highways and railroads. When nesting areas are lost due to a project, it is sometimes possible to replace these with artificial nesting boxes in adjacent areas.

Cultural impacts include the destruction of archaeological sites and the loss of recreational areas. If the former is unavoidable, the artifacts in the area should be relocated before the site is destroyed. If recreational areas are lost, similar areas should be opened up as replacements. For example, the loss of access to a beach can be mitigated by providing a road to a previously inaccessible beach.

The degree to which socio-economic impacts can be mitigated often depends on the political and economic philosophy within the project area. A "free enterprise" philosophy may limit the extent to which a government agency can affect economic programs. However, there are some mitigation measures which can be considered. If a large project is located in a rural area, the influx of construction workers can cause housing problems in adjacent small towns. One alternative in this case would be to build temporary facilities for housing construction workers close to the project site. Once construction is completed, the regular employees of the facility must be provided for on a permanent basis. This can put a strain on the area's infrastructure and services. These will have to be upgraded to cope with increased demand.

Management Measures

Management measures involve the tailoring of process operations to suit environmental conditions. These measures are based on the recognition that there are tolerable levels of impact upon the environment, and that these levels may vary with time. Thus, the object of management measures is to monitor environmental conditions and maintain a "safe" level of impact.

Examples of management measures for impact mitigation are shown in Table VIII.10. Impacts to air and water can be reduced by eliminating pollutant discharges during periods of low assimilative capacity. For air pollutants, this can be achieved by shutting down operations during atmospheric inversion episodes. The water

Table VIII.10: Management Measures for Impact Mitigation

Impact	Mitigation
AIR ENVIRONMENT	
Pollutant Build-up during Atmospheric Inversions	Plant shut-down during inversion.
WATER ENVIRONMENT	
Dissolved Oxygen Depletion during Low Flows.	Retention and regulated discharge of wastes.
OTHER PHYSICAL ENVIRONMENT	
Soil Erosion	Land use rotation so that vegetative cover is maintained.
BIOLOGICAL ENVIRONMENT	
Roadway seperates year-round habitat from mating area.	Close off roadway during mating season.
SOCIO-ECONOMIC ENVIRONMENT	
Overload of services by Construction Workers	Reduce peak number of workers by extending construction period.
Displacement of workers from agricultural lands.	Retraining of displaced workers for employment on new project.

environment can be protected by retention and regulated discharge of wastes. Soil erosion can be combatted by land use rotation. Successive periods of use and rest will help to keep vegetative cover viable, and thus reduce erosion.

Coastal or swamp-side roads often separate a species' year-round habitat from its mating grounds. In such cases it may be necessary to temporarily close the road to traffic during the appropriate season. The overloading of services by construction workers can be reduced if the peak number of workers is lessened. This can sometimes be done by extending the construction period. When a project displaces agricultural workers, it may be possible to re-train these workers for employment on the new project. This will reduce unemployment and emigration.

Policy Revision

After engineering and management measures have been instituted, it still may not be possible to meet existing standards or project criteria. It is at this stage that policy revision becomes necessary. This involves a trade-off comparison between the need to institute the project and the desire to meet standards and criteria. If the net benefits of the project are seen as outweighing the demerits of violating a standard, then a specific exemption from that standard should be sought.

There are two principles that should be observed when a policy revision approach is adopted. These are impartiality and openness. The evaluation of net project benefits should be impartial. The object should be to assess rather than to justify. Some projects are of marginal net benefit. These do not merit an exemption from standards. Others are of great benefit, and the exemption is warranted. However, only an impartial evaluation can determine which is the case.

Openness is necessary to inform the public and to prevent controversy. Many objections to specific exemptions from standards relate less to the project itself than to the way in which the exemption was sought. In matters of this nature, it is vital that the public have access to the following:

- What standards are being violated, and to what extent,
- What adverse effects may result,
- What benefits are anticipated, and
- What engineering and management measures are available to reduce, though not eliminate the violation of standard.

Open exchanges with the public can ease the granting of the exemption which is sought.

A final comment about standards is that they are not absolute. General standards may be over-protective in specific areas. Local standards may have been modeled on standards for other areas, without adequate consideration of local conditions. Older standards may need upgrading. The policy review process can help in bringing these shortcomings to light. When this happens, the review process will actually lead to improved standards. In any case, the review of standards and policy, if conducted impartially and openly, should not be seen as contrary to the objectives of environmental management.

Summary

This chapter has provided examples of techniques which can be used to predict changes due to project impacts on the physical-chemical, biological, cultural and socio-economic environments. It has also addressed impact mitigation by engineering measures, management measures, and policy revisions. The intent has not been to compile an exhaustive list of techniques available. Instead, the aim of the review has been to demonstrate the many and diverse impacts which can be modeled.

Part of the impact evaluation and mitigation process is determining whether project impacts will cause existing standards to be violated. This requires a knowledge of all environmental regulations in force in the project area. In many developing countries, there will be no standards on particular parameters. In that case, desirable criteria should be established in order to evaluate the significance of changes.

It bears repetition that the prediction of impacts is the single most important technical aspect of an environmental study. This being so, use of the most up-to-date prediction techniques is desirable. However, in developing countries that ideal may not be feasible. Factors militating against it are the lack of and/or cost of expertise, data and analytical equipment (such as computers). Because of these limitations, predictive equations are more applicable than more elaborate models at the present time in many developing countries. Some of the air, water, ecosystem and socio-economic models described in this chapter require large amounts of input data for calibration.

Further, some are impractical without a computer. Thus, these models are inappropriate in situations where historical data is lacking and computer hardware is unavailable.

In spite of the limitations noted in the last paragraph, the objective of EIA should be predictions which are as realistic as possible. For this reason, the use of techniques like those discussed in this section is superior to ad hoc or "expert judgment" approaches. Even where expert opinion is the main tool available, such as when evaluating cultural impacts, the use of structured consensus-building methods is recommended.

CHAPTER IX

PUBLIC INVOLVEMENT

This chapter deals with the interaction between the proponents of a project and the public at large. To a large extent, this involves the interrelations between those who would implement the project, and those who would be affected (beneficially or adversely) by it. The interaction may take the form of harmonious partnership, acrimonious confrontation, or any state in between. Ideally, public input should be so harnessed as to enhance the benefits of the project and ease implementation of the alternative which is most generally acceptable.

This chapter consists of five sections. The first deals with the way in which public involvement is perceived in developing countries. This discussion is based to some extent upon the results of the international questionnaire. The second section addresses the extent of public involvement: given specific limitations, how much citizen input is necessary and desirable? The third section deals with techniques by which local social and cultural values can be included in methods for comparing project alternatives. Section four deals with the report of the environmental study. This is referred to as the Environmental Impact Statement in the United States and some other countries. The final section is devoted to the question of conflict management and resolution.

Perceptions of Citizen Involvement

One of the most thorny issues in EIA is public involvement. The very term public involvement will assume different meanings on different projects and in different countries. At the national level, the degree to which public input is sought will depend very heavily on the political and social structure of the society. At the project level, it must be recognized that the nature of a project may limit the free flow of information to and from the society at large. For example, projects associated with national defense will certainly contain aspects which must be kept secret. Thus, the first comment that can be made about public involvement is that it is highly project-specific.

A second comment is that public involvement is not limited to structured forums. In other words, the public will not remain silent simply because its opinion is not asked. It is for this reason that a planned public involvement program is advisable. If the facts are not clearly stated by the project designers, they will reach the public as gossip. If public sentiment is not sought through meetings, questionnaires or opinion surveys, it will be received as protests. Depending on how public input is managed, it may become either an aid or an obstacle to project implementation.

To a very great extent, the effectiveness of a citizen involvement program will depend on how planners and the public view each other. Unfortunately, in many countries, the relationship is one of mutual distrust. In industrialized countries, public participation is often identified with "anti-project" or "anti-government" movements (Delli Priscoli, 1982). This has lead to a negative attitude to citizen involvement in both industrialized and developing countries.

In the Commonwealth Caribbean, as in many newly emerging nations, some leaders view their position as a paternalistic one. They view the public as ignorant, naive children who must be told what is good for them. Such leaders will obviously object to citizen input on matters of importance (Henry, 1972). This image of a public that must be protected from itself is not held only by the political leadership. It may also extend to professionals involved in project planning. Writing of quantity surveyors in Kenya, Gitonga Aritho (1982) questioned whether their role was to help solve local problems, or simply to maintain the status quo.

The other side of the issue is how the general public perceives the public involvement exercise in particular and EIA in general. Shimazu (1980) notes that in Japan, many sectors of the public view environmental studies as a public relations exercise, and nothing else. In such a climate, it is understandable if the public refuses to become involved.

Further insight into the perception of public involvement was gained from the responses to the international questionnaire. In question 37, respondents were asked to rate the importance of the following criterion:

> "Public Involvement: The methodology should incorporate public opinion. The documents produced should enhance public participation."

The criterion is described in such a way that it includes public involvement during the course of the environmental study as well as public response to the study report. The responses from developing and industrialized countries are summarized in Table IX.1.

In all cases, the average rating was in the range average importance to very important. Based on the results of the Kruskal-Wallis test, no significant differences were found among the various geographical regions and levels of development. The same test was performed on the results from developing countries only. Again, no significant differences were found based on level of education, sector of employment or specialized environmental training. These statistical tests can be found in Appendix B.

The responses to the questionnaire do not support the contention that there is less desire for public involvement in the third world than elsewhere. Nor was there any indication that particular groups within the developing countries are more or less concerned with the public's opinion. In every region, there were those who felt that public involvement was extremely important. The minimum rating assigned varied from region to region. One respondent from Africa felt that this criterion was unimportant, and two from the United States felt that it was only marginally important. On the other hand, the minimum rating from the developing countries of Europe was a score of average importance. It must be remembered, though, that the Kruskal-Wallis tests the hypothesis that all samples come from

Table IX.1: Importance of Public Involvement

Note: Regional averages are the mean of county, state or provincial means.

	Regional Rating*		
Region	Min	Avg.	Max
Developing			
Africa and the Middle East	0.00	3.22	5.00
Americas	2.00	4.00	5.00
Asia and Pacific	2.00	3.82	5.00
Europe	3.00	3.67	5.00
Industrialized			
United States	1.00	4.10	5.00
Canada	2.00	4.00	5.00
Other Industrialized	2.00	3.63	5.00

Rating Scale: 0 = Unimportant, ignore factor; 1 = Marginally important; 2 = Moderately important; 3 = Average importance; 4 = Very important; 5 = Extremely important.

identical populations. Thus, the differences in the minimum ratings may not be very important.

Another noteworthy point is that this questionnaire reported the opinions of environmental technologists. If another group had been polled, for example, politicians, the responses may have been different. Further, the sample analyzed does not represent the centrally planned economies of the third world, since no replies were received from those countries. Finally, the attitude of non-respondents is an important unknown. If those who responded are similar to those who did not, then the sample may be taken as representative. On the other hand, it may be that those who responded are interested in EIA while those who did not are not interested. In that case, it is possible that the non-respondents would attach far less importance to public involvement than the respondents did.

In summary, the results of the questionnaire indicated that there is a uniform opinion among environmental technologists that public involvement is an important aspect of EIA. This general perception was independent of level of development, geographical region, education, employment or specialized environmental training. Such a finding is very encouraging, because the success of a public participation program depends upon the commitment of those administering it.

Extent of Involvement

The extent to which the public can be involved in planning a project may be considered as a series of simple questions: Who?, Why?, When? and How? In this section, each of these questions will be discussed. The intent is not to provide universal answers. Instead, the discussions will address certain issues which will assist in answering these questions on a project-specific basis.

Who?

An important part of planning for public involvement is the identification of various "publics" who will be affected by the project. This list must include those who benefit as well as those who are adversely affected. The purpose of identifying the various publics is two-fold. The first is to ensure that no group of persons is excluded from participating. Such exclusion, whether intentional or not, will be resented. Those who are left out will often seek redress outside of the formal public involvement program; e.g., by demonstrations or court action (Schwertz, 1979). The second purpose relates to the public involvement technique to be used. Some techniques are more effective with certain groups than others. This aspect will be dealt with more fully in the "How?" of involvement.

The groups that make up the public may be formal or informal. The first column in Table IX.2 lists some of these groups. This list was drawn up for the United States, but the groups in developing countries are similar. "Individual citizens" is a group which includes every affected person. However, this group considers these persons acting in their private capacity. Thus, the interests of this group will be their basic needs and comforts as individuals. "Environmental groups" may be structured associations or loose alliances. Their

Table IX.2: Effectiveness of Different Media on Various "Publics" (from Canter, 1981c)

Publics	Public Hearings and Meetings	Printed Brochures	Radio Programs and News	TV Programs and News	Newspaper Articles	Magazine Articles	Direct Mail and Newsletters	Motion Picture Film	Slide-Tape Presentation	Telelecture
Individual Citizens	M	L	H	H	H	L	L	M	M	L
Sportsmen Groups	M	M	M	M	M	H	H	H	H	M
Conservation-Environment Groups	M	M	M	M	M	H	H	H	H	M
Farm Organizations	M	M	M	M	M	H	H	M	M	M
Property Owners and Users	M	L	H	H	H	L	L	M	M	L
Business-Industrial	L	L	M	M	M	M	H	M	M	L
Professional Groups and Organizations	L	L	M	M	M	M	H	M	M	L
Educational Institutions	M	L	L	L	M	M	H	M	M	M
Service Clubs and Civic Organizations	L	L	M	M	M	M	L	H	H	M
Labor Unions	L	L	M	M	M	L	L	M	M	L
State-Local Agencies	H	M	L	L	L	M	H	H	H	H
State-Local Elected Officials	H	M	L	L	L	L	H	H	H	H
Federal Agencies	H	M	L	L	L	L	H	M	M	M
Other Groups and Organizations	H	M	M	M	M	M	H	H	H	M

H = Highly Effective

M = Moderately Effective

L = Least Effective

primary interest is usually conservation and protection of the environment. The "business-industrial" group represents the management level of business and industry. It may be formalized, like a Chamber of Commerce, or informal. Its objectives are usually economic growth and development. Membership of the "elected officials" group comes by one's position. The overt interest of this group is to seek the "public good". A covert interest may be to be re-elected to office.

Two comments can be made based on the examples in the last paragraph. The first is that each "public" can be characterized in terms of its membership and its interests. This is true of both formal and informal groups. For example, "farmers" may be a group which has no official association. Yet, for a given project, it would be possible to identify the farmers who would be affected, and to find out what their common concerns are.

The second comment is that some individuals will fall into several groups. This overlap is shown in Figure IX.1. Here, the rectangle represents all individual citizens. A large set within this universe represents labor unions, and a small set represents industry management. These two sets are mutually exclusive. However, some union members and a few managers share a common interest as sportsmen. Such relationships are very important, as they can be used to define "areas of agreement" as a start to conflict resolution.

Why?

The rationale behind public involvement is fairly simple. Public projects are implemented to serve the citizenry. It is

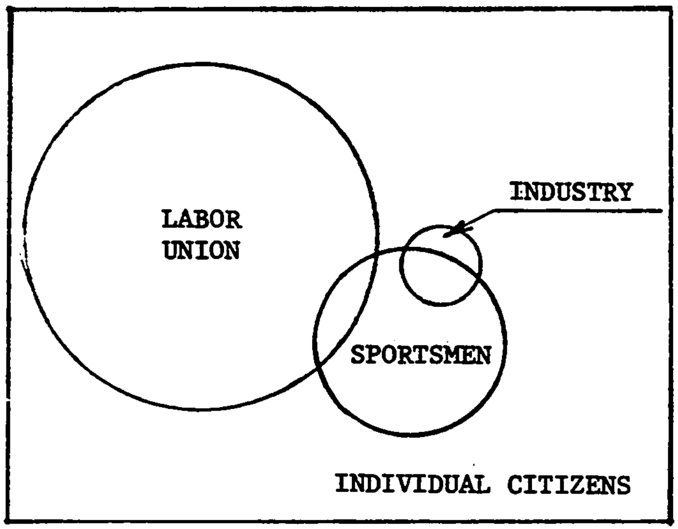


Figure IX.1: Overlap of "Publics"

therefore logical to determine whether the service being provided matches the perceived need. Private projects may be implemented for personal gain. In this case, public involvement is needed to ensure that "one man's gain" does not become a "poison" to society.

A second aspect of the "Why?" question is the objective of public participation. Bishop (1975) has listed six objectives of public involvement. These are:

- to inform or educate the public;
- to identify problems, needs and values;
- to seek approaches to problem solving;
- to seek reaction (feedback) on proposed solutions;
- to evaluate alternatives; and
- to resolve conflicts.

The need to inform or educate the public stems from the fact that the public may be unaware of the need for action. They also must be told of the alternatives being considered. Thus, the inform/educate objective involves information about the general problem being addressed as well as the specific actions being proposed.

Public input can assist in identifying problems, needs and values. The project will be initiated in response to one problem or need. Public involvement can identify other needs and problems which should be included in the assessment of alternatives. The values of the people being affected are a necessary input in the comparison of alternatives.

In some cases, the public can suggest approaches to solving specific problems. "Local" solutions which are most acceptable to the affected public might be overlooked by outside consultants. It should not be assumed that these inputs are without merit.

Communication is a two-way process. If an effective feedback is established, conflicts can be settled in an atmosphere of co-operation, rather than antagonism.

The evaluation of alternatives can be structured to include a high degree of public input. If the weighting of factors is based on local values, then the proposed action will be more readily accepted by the affected public.

Conflict resolution and concensus building are important aspects of project implementation. The ideal in public participation is a situation in which all parties concede the necessity of the project, and no-one sees himself as a "net loser".

When?

Public involvement, to be effective, should run throughout the duration of the environmental study. However, the objectives of this involvement will change at each stage of the study. Table IX.3 summarizes the objectives of public input at various stages in an EIA.

The initial identification of impacts is done to establish the scope of the environmental study. Public involvement at this stage is primarily devoted to informing the public about the project and getting to know what citizens feel about the problem being addressed. At this early stage, it will be possible to start identifying which groups see themselves as "winners" and which as "losers". The effort by the

Table IX.3: Public Involvement Objectives at Various Assessment Stages (Bishop, 1975)

Objective	Assessment Stage: Impact Identification (Scoping)	Baseline Study	Impact Evaluation	Mitigation Planning	Comparison of Alternatives	Decision-Making
Inform/Educate	X	X	X	X	X	X
Identify Problems/ Needs/Values	X	X	X	X	X	
Approaches to Problem Solving			X	X		
Feedback		X	X	X	X	X
Evaluate Alternatives			X	X	X	
Resolve Conflicts					X	X

project planner should be to establish rapport and an air of cooperation.

The baseline study records the environmental status quo in the project area. At this stage, the flow of information to the public takes the form of what is being surveyed and why. Feedback to this information is often helpful in identifying existing data bases and sources. Thus, the public's response can reduce the time and cost of the baseline survey. Citizens can also identify areas of particular local interest which should be highlighted in the environmental report.

Impact evaluation consists of the prediction of changes due to project alternatives. The public can assist in this process in several ways. By reviewing the project alternatives being considered, they can ensure that no viable alternative is inadvertently omitted. Where legal standards are not in force, comments from the public can be useful in establishing project-specific criteria on maximum tolerable levels of change. Finally, the information-feedback cycle must be maintained to hold the public's interest and prevent alienation.

Mitigation measures are planned to reduce undesirable project effects. One of the major public inputs at this stage is ensuring that the mitigation measure is itself acceptable. Consider, for example, a new housing development that draws heavily on an existing water supply. One mitigation measure is to collect and treat wastewater from the urban area and recycle it. In many areas this measure, though technically feasible, is culturally unacceptable. As before, public review will ensure that all reasonable measures are considered.

The comparison of alternatives is done to determine the one or several preferred actions. Local values should be used to weight the importance of environmental factors at this stage. Some of the techniques which can be used to incorporate local social and cultural values into assessment methods will be discussed in the next section. It is very important at this stage that the public have an input into what is recommended to decision-makers.

It is at the comparison of alternatives stage that the preferred project alternative is identified for the first time. It is therefore at this stage that conflicts will come clearly into focus. Methods of conflict resolution will be discussed in the last section of this chapter. If the public involvement program has been effective to this point, it should be possible to resolve conflicts in a spirit of cooperation.

The final step in an environmental study is the actual decision on which alternative will be implemented. At this stage, public involvement has three objectives. The public should be informed what the decision is and why. Ideally, the decision should be based on the recommendations arising out of the comparison of alternatives. However, this is not always the case. The second objective is final resolution of conflicts. It may be necessary to compensate certain publics in order to even out the distribution of benefits. Finally, if the decision-makers are responsible to the public, there will be feedback concerning the final decision.

How?

The final question in defining the extent is "How?". Public involvement techniques can be divided into three categories: public forums, community contacts and interactive group methods. Examples from each category are shown in Table IX.4. The usefulness of each technique in achieving the six objectives of public involvement is indicated.

Public forums include meetings, hearings, small informal meetings, presentations and coordination seminars. Public hearings are formal and highly structured. Traditionally, they have been used in circumstances where a formal record or transcript is required. A major benefit of this technique is public acceptance. Many citizens see hearings as the most important arena where their views must be voiced. However, there are disadvantages. First, there is no guarantee that the collection of views stated is representative of the community. In areas where public involvement is a new idea, only persons with special interests may attend hearings. Secondly, the statements presented may be very open-ended and difficult to interpret. This is especially true when the project plans are unveiled for the first time at the hearing (Bishop, 1975).

Public meetings are less formal than hearings, and a transcript is not required. However, notes of these meetings should be kept. General public meetings have the same advantages and disadvantages of hearings, but lack the formal, rigid structure. This leads to a more open exchange of ideas. The meeting might be enhanced if a respected member of the local community acts as chairman. In developing

Table IX.4: Capabilities of Public Involvement Techniques in Developing Countries (Adapted from Bishop, 1975)

Public Involvement Technique	Objective					
	Inform/ Educate	Identify Problems/ Needs/Values	Problem Solving	Feedback	Evaluate Alternatives	Resolve Conflicts
PUBLIC FORUMS:						
Public Meetings	X	X		X		
Public Hearings		X		X		
Small Group Meetings *	X	X	X	X	X	X
Presentations	X	X		X		
Co-ordination Seminars	X			X		
COMMUNITY CONTACT:						
Field Office *		X	X	X	X	
Visits*	X	X	X	X	X	
Brochures/Pamphlets/Workbooks	X		X	X	X	
Displays/Models *	X		X	X	X	X
Mass Media *	X					
INTERACTING GROUP METHODS:						
Workshops *		X	X	X	X	X
Charettes			X		X	X
Task Force *		X	X		X	
Community Residents *		X	X			X
Representative *		X	X	X	X	X

*Most effective methods.

countries, this may be a tribal chief, village elder or some other social leader.

Small group meetings may be seen as small-scale public meetings which allow closer contacts between persons from various publics. The objective is again to present information and seek feedback and opinions. The format is that of a round-table discussion, with a leader who maintains order but does not attempt to overly control discussions. If there are regular community meetings within the project area, small-scale public meetings can be effectively integrated into these.

Presentations to organizations are similar to small group meetings. However, the audience is usually composed of one "public". Hence, the presentation can be tailored to suit that audience. The usual format is a prepared statement about the project, followed by a question and answer period.

Coordination seminars are not used to inform the general public. Instead, they are aimed at coordinating the efforts of specific groups and individuals. They are an excellent method for keeping persons up-to-date, providing specialized information, and clarifying policy.

Community contact techniques include field offices, site visits, brochures/pamphlets/workbooks, displays/models and use of the mass media. Here, the planner, acting in his role as an "expert", provides information to the public. The key is that the planner reaches out with information, instead of passively awaiting questions.

Field offices are the centers of operation in studies which require close contact with the community. They can also be used to disseminate information to the public. At times, the mere presence of a field office will reduce the feeling of alineation between planner and public.

Site visits can be used instead of field offices if the main design office is close, or if the volume of site work is too small to justify a site office. These visits are normally geared towards coordination of other public involvement techniques, but they can serve to answer questions and provide information.

Brochures, pamphlets and workbooks can all be circulated within the community to increase public awareness of a project. To be most effective, these techniques should be a continuing exercise. For example, the first brochure could be introductory, describing the project. The next would respond to questions raised by the public and provide specific data. The third round would solicit opinions on sensitive matters, etc.

Displays and models can be used, where appropriate, to demonstrate special aspects of the project. The idea is that persons without technical training may be reached more effectively through these visual presentations than through lectures or printed data.

The use of the mass media in communicating with the public must be carefully planned. Three key aspects will be mentioned here. First, the organ of communication should be credible to the public. If a project uses a newspaper, say, that has poor credibility in the community, then the project will be viewed with suspicion. Secondly, sensationalism must be avoided. For this reason, project planners must maintain control over what is broadcast or printed. Finally, different reports must be consistent. This is achieved by coordination of press releases.

Interactive group methods are characterized by a high degree of two-way communication. They include workshops, charettes, task forces, employment of community residents and site representatives. These techniques are efficient in presenting, discussing and receiving data; identifying and resolving conflicts; and determining public needs and attitudes.

Workshops depend, to a large extent, upon advance preparation. The system assumes that all participants are well informed about the project, and have come prepared to discuss certain pre-determined issues. Under such circumstances, a large volume of relevant information can be considered in a relatively short space of time.

Charettes are highly intense, resolution oriented "mini-workshops". A small group is selected to meet for the purpose of reaching a decision or resolving a conflict. There are two important keys to success. The first is that the group contains the appropriate people tc do the stated task. Secondly, each group member must be fully conversant with the project as a whole and with the specific issue at hand.

The final three techniques in Table IX.4 all involve an intermediary between project planners and the general public. This approach may be necessary if a good rapport does not exist between planners and public. A task force of citizens can be formed to advise planners of local preferences and to work towards solution of particular problems. This task force should be made up of persons who can fairly represent local values, and who are willing to work with the project planners. Another alternative would be to employ a member of the community to serve as a liason between project and public. This person must be respected and approachable by the public. The third alternative is to appoint a member of the planning team as site representative. This person will then have to try to build a rapport with the community in order to function as an ombudsman.

In Table IX.4, public involvement techniques which can be used to achieve each of 6 objectives are indicated. In addition, those techniques which would be especially effective in developing countries are marked with an asterisk. In general, the effective techniqus are those which graphically display a project and its impacts, those which "reach out" to a community, and those which foster a sense of meaningful participation. If the literacy rate in a community is low, special care must be taken to ensure that suitable graphics are prepared. Where public participation is a new concept, a certain degree of apathy is to be expected. Thus, the project promoters will have to take the first step to establish contact with the affected community. Finally, people would like to see some tangible results from their input.

Among the public forums, the small group meeting is probably the most effective. In the less formal setting, people are more willing to speak freely. This is especially true if the project meeting is incorporated into another regular community gathering. However, there will be situations where more formal forums are desirable.

Of the community contact techniques, field offices or visits fulfill the "reaching out" role. The very fact that the project proponents are near at hand will encourage dialogue. Displays, models and the mass media can be used to effectively display the project and its impacts.

Among the interacting group methods, community residents or representatives can fulfill the "reaching out" role if field offices or frequent site visits are impractical. They can also be instrumental in resolving conflicts if they have the trust of the various groups in the community. Workshops and task forces give participants a real feeling of participation, especially during the evaluation of alternatives.

Planning

It was stated at the start of this section that the public involvement exercise should be project-specific. In fact, it is useful to decide upon a public involvement program early in the environmental study. This program should not be a rigid one. It should be sufficiently flexible to cater to unforseen problems as they arise. However, it should be definite enough to allow optimum use of public input in project planning and the environmental study. The following is a sequence of steps which may be used when planning a public involvement program:

1. Identify Publics: During the impact identification stage of the environmental study, identify the groups which will be affected by the project. Note the special characteristics of each group: are they formal or informal, what is the approximate size of each, are they traditionally active in public forums, etc.

2. Identify Constraints: There may be political, social or cultural constraints on the public involvement program. These must be identified early. The public should not be led to believe that their input can effect greater changes to the project than is actually the case. Examples of projects which have constraints on public involvement are military and security programs.

3. Define Objectives: Within the constraints identified in (2), the objectives of the public involvement program should be set out. Examples of objectives were shown in Table IX.3.

4. Decide on Timing: Depending upon the objectives defined in (3), the timing of various involvement techniques can be decided. The relationship between public involvement objectives and environmental study stages was summarized in Table IX.3.

5. Decide on Techniques: The actual techniques to be used in public involvement will depend upon the publics and the objectives of the program. Techniques which are effective in reaching various publics are summarized in Table IX.2. The capabilities of techniques in achieving different objectives were shown in Table IX.4.

A well-planned public involvement program is a necessary first step to citizen input and acceptance of the project. Successful implementation of the program will depend upon commitment from both the planners and the community. The remainder of this chapter is devoted to three aspects of the planners' task which relate to public involvement. These are the incorporation of local values into the comparison of alternatives, the documentation of the environmental study, and the management and resolution of conflict.

Incorporating Local Values

It may be decided that local values should be incorporated into the methodology used to compare alternatives. Three techniques for doing this will be briefly discussed here. The first is the ranking of alternatives by a panel of citizens. In this technique, a representative group is fully briefed on all aspects of each alternative. The group then meets, discusses and finally ranks the alternatives based on their knowledge of local values and preferences. There are several limitations to this approach. The major ones are representation and conflict of interest. It is very difficult to select a panel which is truly representative of the community. Once selected, the individual members may choose the alternative which best suits their personal interests, rather than the interests of the community as a whole. In spite of these difficulties, the ranking approach can be used to narrow down a large field of alternatives to a few for more intensive study (Canter, 1979b).

A more systematic approach is to have the panel assign importance weights to parameters on a weighting-ranking or weighting-scaling checklist without detailed knowledge of the actual alternatives. When this is done, the resulting checklist reflects local values and preferences. However, because the panel works on the checklist rather than the alternatives, conflicts of interest are reduced. One technique for assigning weights is pairwise comparison. This was discussed in detail in Chapter VII. The panel, working individually or as a group, ranks the parameters on the list. These are then converted into importance weights using pairwise comparisons (see the WRAM method for comparing alternatives in Chapter VII).

The Delphi technique can be used to assign weights as well as to determine scaling functions. This method of reaching concensus was described in the section on "Cultural Impacts" in Chapter VIII. There are two examples of its use to develop weights and scaling functions for checklists. Both involve the Battelle EES. Toussaint (1975) used a Delphi to develop weights and scales that were reflective of values in the South-West United States. Lohani and Kan (1981) used the technique in Thailand.

Table IX.5 compares the results of these two studies with the original Battelle EES. In part (a) of the table, it can be seen that the Thai system included fewer parameters than the original. Also, the greatest importance was placed on the Human Interest category, instead of the environmental pollution category in Battelle. If the Thai system is taken as a representative weighting system for developing countries, and the Battelle EES as a representative weighting system for industrialized ones, then Lohani and Kan's Delphi results were not inconsistent with the results of the international questionnaire. Even though a direct comparison is not possible, a similarity of trends is noted. Both the Battelle and the Thai systems assign similar total importance weight to the biological environment. This is in agreement with the questionnaire results, where biological importance ratings were found to be independent of level of development. Respondents to the questionnaire from the third world tended to rate physical parameters lower than their counterparts from the industrialized nations. This compares favorably with the importance weights on Table IX.5. Overall, the physical-chemical environment is weighted noticeably lower in the Thai EES than in the Battelle EES. Looking at specific parameters related to water quality, it is noted that each is weighted less in the Thai system than in either the Battelle or the South-West U.S. System.

Table IX.5: Local Values Applied to Scaling-Weighting Checklists (Dee, et al., 1972 and 1973; Lohani and Kan, 1981; and Toussaint, 1975)

a) Overall Point Distribution

Category	No. of Parameters		Points	
	Battelle EES	Thailand	Battelle EES	Thailand
Ecology	18	12	240	279
Physical-Chemical/ Environmental Pollution	24	21	402	280
Aesthetics	17	5	153	87
Human Interest	19	12	205	354
Total	78	50	1000	1000

b) Surface Water Parameters

Parameter	Points		
	Battelle EES	South-West US	Thailand
Basin Hydrologic Loss	20	16	7
BOD	25	21	7
Dissolved Oxygen	31	31	11
Fecal Coliforms	18	25	-
Inorganic Carbon	22	16	-
Inorganic Nitrogen	25	21	5
Inorganic Phosphate	28	24	5
Pesticides	16	30	8
pH	18	16	6
Stream Flow Variation	28	20	11
Temperature	18	28	8
Total Dissolved Solids	25	25	8
Toxic Substances	14	14	7
Turbidity	20	20	7
Total	318	307	90

Cultural and socio-economic parameters are both included in the human interest group, and aesthetics is a cultural parameter. It is therefore difficult to determine whether the relative weightings of the cultural and socio-economic environments in the two systems follows the same pattern as the responses to the questionnaire.

Points awarded to the surface water parameters are shown in (b) of the table. The South-West U.S. system assigns approximately the same number of points as the Battelle system in this category. However, the former attaches greater importance to fecal coliforms and pesticides, and slightly lower points to the other parameters. The Thai system excludes two parameters, and awards generally lower points throughout this category.

Documentation

The environmental impact statement (EIS) or environmental study report is the written output of the environmental study. This document is important for two reasons. It is the basis for decision-making, and it is reviewed by concerned persons. For the latter reason, the study report becomes part of the public involvement exercise. This section outlines a few options for making the document more readily understandable to the general public.

Contents

In countries where EIA is a legal requirement, the format and contents of the EIS may be dictated in the legislation. Examples include the United States of America, Colombia (INDERENA, 1981), Venezuela (Mejia, 1979), the State of Victoria, Australia (Ministry for

Conservation, Victoria, 1981), and the Province of Onterio, Canada (Ontario Ministry of the Environment, 1981). In other countries, the contents of the document is more flexible, and can vary from project to project. Regardless of the format, however, the document must recommend a proposed course of action and provide technical justification for the recommendation.

A review of EIS formats in the five countries listed in the previous paragraph yielded several aspects common to most. These are listed below. The order in which they appear in the document varies.

1. Description of Problem or Opportunity: Every project is designed to solve a problem or take advantage of an opportunity. The description of the problem or opportunity establishes the need for the project.

2. Description of Alternatives: All feasible alternatives, including the no action alternative, should be considered. Alternatives which were rejected should be listed, giving reasons for rejection.

3. Description of Affected Environment: Here, the results of the baseline survey are reported.

4. Prediction of Effects: The environmental impacts of all feasible alternatives should be included. These should include beneficial and adverse effects, direct and indirect, reversible and irreversible, as well as long-and short-term.

5. Mitigation Measures: Practical means of avoiding, minimizing or ameliorating adverse impacts should be described.

6. Recommendation: The method used to compare alternatives must be outlined. The proposed course of action, including mitigation measures, should be clearly stated.

7. Review Comments: The final document should contain comments received from reviewers, and a discussion of these comments as appropriate.

8. <u>Summary</u>: A summary of the findings and recommendations of the environmental study is greatly recommended. This summary should be brief and to the point.

Technical Level

The EIA report is a technical report. Thus, it should contain sufficient data to permit meaningful review by technically trained persons. However, inclusion of an abundance of technical information may tend to alienate reviewers who lack a technical background. The desired middle course is a report which is understandable by the lay public but sufficiently detailed for technical review. This can be achieved by judicious distribution of material between the summary, the text of the report and the appendices.

The summary of an EIS should be written for a very general audience. It should concentrate upon the findings and recommendations of the environmental study. However, it should not contain technical data or calculations. Persons who wish to review further would be referred to the main text of the report. In the case of a lengthy EIS, the summary should be separately bound. This would permit very wide distribution at relatively low cost. Again, persons who wish to review in greater detail can then obtain copies of the text of the EIS.

The main text of an EIS should be written for a technically-trained audience, but not necessarily for review by specialists in each environmental area. The objective here is to present a whole picture of the study area, project alternatives and recommendations. The baseline study and predicted levels of impact should be included, and the method used to compare alternatives should be described. All assumptions should be clearly stated in the text, and sources of data referenced. However, detailed calculations need not be presented. Examples of detailed calculations are those necessary to quantify impacts. Reviewers who wish to check individual calculations would be referred to the appendices.

Appendices to an EIS should contain as much detailed technical material as is desirable to explain the findings and recommendations of the environmental study. They should be written for an audience of technical specialists who would want to do detailed checking of calculations. Based on the three levels of reporting just described, it should be possible to produce a document which satisfies all sections of the public.

Dos and Don'ts

Hellstrom (1975) prepared a list of dos and don'ts for use by EIS writers. These are summarized as follows:

- Don't produce needless volume. Avoid repetition and irrelevance.
- Don't be evasive. Include all important points.
- Don't exaggerate benefits or down-play adverse impacts.
- Don't be flippant or casual.
- Don't use unsupported opinions or personal value judgment.
- Do be brief, accurate, clear and factual.
- Do write each section to a specific audience.
- Do use clear illustrative material.
- Do be objective and thorough.
- Do establish rapport with the general public.

Summary

The EIS is a report which is written for a variety of audiences and with a variety of objectives. As a recommendation for action, its audience will be decision-makers. As a tool for public involvement, it will be reviewed by persons with very different technical backgrounds. The ideal is a document which serves the needs of each reader. This can be achieved by writing different parts of the report at different technical levels, as has been discussed in this section.

Conflict Management and Resolution

If a project can be structured in such a way that all parties gain and none loses, there would be no conflict and thus no need for conflict management. Unfortunately, this ideal is rarely if ever the case. In the vast majority of cases, some sections of the community see themselves as "losers" and others as "winners". In many cases, too, some groups become "winners" in some aspects and "losers" in other aspects. Conflict arises when a group believes that the net gain of the project comes at their expense but goes to someone else. In this section, some of the key issues of conflict management will be discussed. These include the types of conflict, the role of a third party concilliator, an approach to concensus formation and an approach to problem solving.

Types of Conflict

The first comment that should be made about conflict is that it can be a useful, positive function of society. It serves as a safety valve where the interests of different groups are in opposition, and can be the instrument of evolutionary change. Unfortunately, mismanaged conflict can become a distructive force. Examples of this abound. Behind every violent protest is a group who feels that their views are being suppressed and ignored. The solution to conflict is neither to avoid (ignore) it nor to "keep the lid on". Instead, the source of conflict must be identified, and an attempt made to achieve consensus. In order to do this, it is instructive to look at the various types of conflict which may occur.

Creighton has identified four kinds of conflict: cognitive, values, interest and relationship (Creighton and Delli Priscoli, 1981). Cognitive conflict is a difference of opinion about the facts of a case. The problem here is a question of interpretation or understanding of a project's effects. One example would be a flood control project. The basic question would be whether or not the designed project can provide an adequate level of protection.

Values conflict relates to whether or not an outcome is desirable or undesirable. Different groups would place different relative weights on different aspects of a project, leading to differences in the alternative to be chosen. Consider, for example, an industrial development. The business community would want it sited close to the product market, in order to reduce distribution cost. The citizens of the customer community will want the plant sited some distance away, for safety and aesthetic reasons. Thus, the differing values of the two groups result in a conflict.

Interest conflict relates to the concept of "winners" and "losers". Those who expect to gain will have an interest in project implementation. Others will have an interest in halting the project. A good example of interest conflict was the Caroni-Arena Water Supply Project in Trinidad, West Indies. There, a dam and reservoir were built in a remote rural area, and the water piped to urban areas. Naturally, this project was in the interest of town-dwellers, but objected to by displaced farmers. However, all parties agreed that more potable water was needed.

It should be noted here that there is considerable overlap between cognitive, values and interest conflict. In most cases, all three types co-exist and inter-relate. For example, group values will determine whether a sector of the population sees itself as a "net winner" or "net loser". Similarly, arguments over facts may be central to arguments about values or interests.

The final type of conflict, relationship conflict, is psychologically-oriented. This is perhaps the most difficult type of conflict to resolve. One common source of relationship conflict is the perception of favoritism. One group may feel that its views are being ignored, or that the views of another group are being given special attention. The result is an anti-project reaction. However, this is directed against the way the project is being managed rather than the project or any specific part of it. Another source of relationship conflict is individuals who are inherently aggressive. This type of personality will not be satisfied with compromise, since their interest has very little to do with the project. In general, the resolution of relationship conflicts will require an understanding of their psychological causes.

Conflicts may also be typefied by the attitude with which resolution is attempted. Two basic scenarios are "winner-loser" and "all winners" (Creighton, in Creighton and Delli Priscoli, 1981). The winner-loser scenario assumes that one party stands to gain while another stands to lose. As a result, the atmosphere is one of antagonism, with each party attempting to minimize its losses and maximize gains. The all winners scenario assumes that both parties stand to gain, and both will share the costs of the project. In this case, the objective becomes one of maximizing overall project benefits and minimizing overall cost. The key difference between the two scenarios lies in the fact that the overall maximum benefit can be greater than the sum of maximized individual benefits to parties. Thus, by working together and trading off overall costs and benefits, a greater good can be derived from the project.

Third Party Intervention

In some cases, the resolution of a conflict can be facilitated by a third party concilliator. In other cases, third party intervention may only serve to make the situation worse. The first decision, therefore, is whether third party intervention is appropriate in a particular dispute. Wehr (1979) established five criteria to aid in making this decision. These are:

1. Accessibility: Can a third party gain entry into the conflict? Do the conflicting parties view it as a "private dispute"?

2. Tractability: Does the conflict offer some hope of successful resolution?

3. Divisibility: Can the conflict be subdivided into smaller, more managable segments? Can the third party intervene in only one segment?

4. Timing: Is it too early or too late to intervene?

5. Alternatives: Is intervention risky to successful resolution? Would non-intervention be a less risky course of action?

If it is decided that third party intervention is appropriate, the next step is selection of a concilliator. There are two qualities which are essential in the intervenor: credibility and neutrality. The conflicting parties must believe that the concilliator is sincere in his job. He should be a person who has a good reputation, has successfully resolved disputes in the past, and has some authority. Secondly, he must have no vested interest in the dispute except the desire to see it settled.

Once a concilliator has been chosen, there are certain skills which will facilitate his work. Wehr (1979) has summarized ten of these skills.

1. Analysis/Fact Finding: Be able to identify and clarify parties, issues and goals.

2. Empathy: Understand the positions of conflicting parties without agreeing with them.

3. Listening: Parties must be given an opportunity to air their views. This may also vent frustration and hostility.

4. Timing: Must be able to judge when parties should be brought together, and when they should be kept apart.

5. Trust: Must develop credibility with all parties.

6. Mediation: Ability to help formulate mutually agreeable solutions and help evaluate trade-offs.

7. Communication: Must facilitate communication between parties. Can assist in "unscrambling" messages.

8. Creativity: Should be able to devise imaginative solutions which may not be apparent to conflicting parties.

9. Costing: Ability to demonstrate to each party the cost of conflict and the benefits of resolution.

10. Crisis Management: The control of rumor, tension, hostility and open violence.

Negotiations

At some point during conflict resolution, the disputants must meet face-to-face to negotiate a mutually acceptable solution. This meeting must be carefuly controlled, or it can degenerate into a shouting match. If negotiations are to be successful, all affected parties should be included. However, it is sometimes necessary to exclude all others. The presence of "observers" may retard progress because negotiators may assume extreme positions in the presence of witnesses. It is vital that the representatives of each party be persons with authority who can make commitments on behalf of their group. Creighton has summarized the usual negotiating procedure into a four-step strategy (Creighton and Delli Priscoli, 1981). This strategy can be used whether the disputants are political factions, labor and management, countries, or developer and citizen. The four steps are as follows:

1. Areas of Agreement: Parties enumerate all areas on which there is agreement. These are then eliminated from discussion. This step saves time later on and, most important, establishes common ground and fosters a feeling of mutual trust.

2. <u>Areas of Disagreement</u>: Parties clearly define all areas of disagreement. Each party must state its position on each point of conflict, giving the underlying reasons for its position. This gives negotiators an idea of the magnitude of the problem. It also ranks points of conflict in a rough order of importance.

3. <u>Conflict Resolution Procedure</u>: If possible, a procedure for resolving disagreements should be agreed upon. Doing this establishes a suitable climate in which agreements can be made.

4. <u>Negotiate Issue-by-Issue</u>: It is not usually possible to resolve all outstanding disagreements at once. A more realistic approach is to try and solve points of conflict one at a time. It may be advisible to negotiate minor issues first and then progress to major ones. In this way, the negotiators will address the more difficult problems having a record of successful negotiations on less thorny issues.

Solving Specific Problems

The last step in the strategy just described involves solving specific problems. Creighton has outlined a five-step process for problem-solving (Creighton and Delli Priscoli, 1981). These five steps are described below.

1. <u>Define Problem</u>: It is essential that all parties agree upon what the problem is, and why it is a problem. This step ensures that all are working to solve the same problem; that any deeper problems are identified; and that pre-conceptions as to solution are avoided.

2. <u>Develop Solutions</u>: Each party should identify as many alternative solutions to the problem as possible. No attempt should be made to evaluate at this stage. All alternatives, regardless of how far-fetched they may appear, should be described and listed.

3. <u>Evaluate Solutions</u>: Each alternative should be criticized by all parties. Strengths and weaknesses should both be addressed. Generally acceptable parts of different alternatives should be noted, since the final plan may be a composite rather than a single alternative.

4. Mutually Agreeable Solution: The aim here is to seek a consensus instead of a majority decision. As a result, minority opinions must be considered rather than voted down. If a consensus is difficult to achieve, it may be necessary to review the problem definition, seek additional alternatives, or re-evaluate alternatives. Discussions should continue until all parties can accept one solution.

5. Formulate Plan of Action: When a mutually agreeable solution is reached, the means of implementing it must be decided. All parties can give their ideas on how best this can be done. Before closing the problem-solving exercise, all participants must have a clear idea of what is to be done, and by whom.

Summary

Conflicts are an integral part of human relationships. Properly managed, they can be a useful, positive function of society. The actual process of resolution will be determined by the society in which the disagreement arises. However, regardless of differing social customs, two elements are necessary if environmental disputes are to be successfully resolved. The first is a genuine desire on the part of the disputants to reach an agreement. Second, if a mediator is appointed, that person must be impartial, and trusted and respected by the disputants.

The mechanics of the overall public participation program are also project- and country-specific. Social and political norms will dictate the manner in which citizen opinion is sought and offered. Here again, though, there are two essential ingredients for success. The first is commitment to the concept of public involvement by proponents of the project. The second ingredient is a belief by the population that the process works.

CHAPTER X

CONCLUSIONS AND RECOMMENDATIONS

The conclusions and recommendations in this chapter are summarized from Chapters VI, VII, VIII and IX. Therefore, all statements made here are subject to any constraints noted in the appropriate chapter of the report. The conclusions and recommendations in this chapter are based upon the literature review, the responses to the international questionnaire, and the ranking of EIA methods and techniques. They are grouped under three headings: current status, EIA methodologies and future work. The first section relates to EIA laws and practice, availability of data and expertise, attitudes to public involvement, and environmental priorities. The second section contains conclusions about methodologies for impact identification, baseline studies, impact evaluation, and comparison of alternatives. The final section recommends further work.

Current Status

The first objective of this study was to determine the status of EIA in developing countries. From the responses to the international questionnaire, it was possible to summarize the status of EIA laws and practice in both developing and industrialized nations. It was also possible to compare environmental perceptions in the third world with those in the industrialized countries. The conclusions are as follows.

Laws

The spread of laws requiring environmental studies on major projects has been quite rapid in the last decade. Of the 72 developing countries which responded to the questionnaire, 39 (54%) had such laws. This compares with 17 (76%) of the 22 industrialized nations which responded.

Practice

The growth of EIA practice has been even more rapid than the spread of laws. This is due, in part, to the impetus provided by the international lending agencies. Of the third world nations responding to the questionnaire, 77% (55 of 72) had experience with environmental assessments. Among the industrialized countries which responded, this proportion was 95% (21 of 22).

Data

The unavailability of data is commonly cited in the literature as one of the major problems faced by developing countries. Some respondents to the questionnaire supported this view. The use of secondary data was considered very important in all but two countries. The exceptions were the United States and Canada.

Expertise

A second problem that was often cited in the literature was the unavailability of expertise in the third world. This view was strongly supported by respondents to the questionnaire. A majority from the industrialized world felt that there were enough trained personnel available, while a majority from the developing countries felt that there were not. Specifically, there was a paucity of numbers in industry and consulting in the third world. All regions felt that it was quite important for EIA methods to be usable by the technologists who are available.

Public Involvement

All regions rated public involvement at above average importance. Adverse comments were received from both developing and industrialized countries. The view that public participation is not encouraged in the majority of third world countries was not supported by the results received.

Priorities

Some authorities contend that the socio-economic environment is considered most important in developing countries, and the physical-chemical, biological and cultural environments less important. This was not supported by the responses from the third world countries of Europe and the Americas. It was only mildly supported by responses from Africa and the Middle East and Asia and the Pacific.

In general, the importance rating of parameters was dependent upon the immediacy of the problem. Parameters received higher ratings in regions where their ill-effects are known, and lower ratings where they are not seen as a likely problem. There was no clear trend in the ratings which could be definitely associated with levels of development.

EIA Methodologies

Based on the literature reviewed and the responses to the questionnaire, a conceptual framework for EIA in the third world is proposed (see Table VI.19). This proposal differs from the more traditional approach in two ways. First, the environmental study is parallel to and concurrent with the engineering design. Traditionally, EIA's have been reactive, coming at the end of the engineering study. Second, the decision-making step is listed separately from the comparison of alternatives. It was felt that this more accurately reflects the division of authority in the third world (and perhaps in some industrialized areas). The framework consists of nine steps, and different methodologies may be used at each step. The conclusions relative to EIA methodologies are as follows.

Impact Identification

Checklists, matrices and networks can all be used to identify the impacts of a project. Based upon the importance rating of three criteria, it was determined that checklists are most appropriate for the third world at this time, followed closely by matrices. Networks were the least appropriate. Not surprisingly, the methods which were specifically formulated for use in developing areas ranked the highest. These were the UNEP checklist for siting of industry and the USAID checklist for rural development projects.

Baseline Studies

Checklists, matrices, structured habitat approaches and index methods are all useful in planning and conducting the baseline study. Whatever method is used, it is important that it be comprehensive. The UNEP baseline summary tables are a good example of a comprehensive checklist for planning the baseline survey. Further, the baseline study should address the impacts which were identified during the scoping step, and should collect the type of data which would be needed during impact prediction. In other words, there should be a logical sequence from scoping to baseline study to impact evaluation.

Impact Evaluation

Impact evaluation includes impact prediction and mitigation planning. For these steps, respondents rated two criteria, objectivity and quantification, as being very important or extremely important. In general, mathematical, statistical or other numerical methods were more acceptable than "expert opinion" approaches. Further, quantitative assessments were superior to descriptive ones.

Because of the limitations on data, trained personnel and computer hardware which commonly exist in developing areas, the use of predictive equations is probably most realistic at the present time. The limitations just mentioned will probably render the use of more elaborate computer-based models impractical. Examples of predictive equations are the Gaussian models of air pollution dispersion, the oxygen sag curve for residual oxygen in water, Chick's law of microbial die-off, and the gravity technique for settlement patterns. The fact that the more elaborate models cannot be used now does not mean that they never will be applicable. What is required is the establishment of monitoring programs in areas of concern, to build up data bases.

Comparison of Alternatives

Matrices, different types of checklists and a cost-benefit analysis were all evaluated based upon the importance ratings of five criteria. Scaling-weighting checklists rated most appropriate for use in the third world, followed by matrices. Scaling checklists and the cost-benefit analysis were found to be least appropriate. The two scaling-weighting checklists which were ranked as the most appropriate methods for developing countries were the Water Resource Assessment Methodology (WRAM), and the Battelle Environmental Evaluation System. Both of these methods can be adapted to reflect the values of the country in which they are being used.

Public Involvement

The public involvement techniques which would be most effective in the third world are:

- -- those which graphically display a project and its impacts;
- -- those which "reach out" to the community; and
- -- those which foster a sense of meaningful participation.

Of the public forums, small group meetings are probably most effective. Among the community contact techniques, the most effective are field offices or visits, displays, models and the mass media. The most effective interacting group methods are workshops, task forces, community residents and representatives.

Future Work

The most significant result of this study is that there were no dramatic differences in the perception of environmental affairs between technologists from developing nations and those from industrialized countries. Thus, there is no obvious reason why EIA should not be adopted as a useful planning tool in the third world. Even though it was acknowledged that EIA would increase the cost of projects, there was still support for the process. This implies that respondents felt that the benefits of a proper assessment would outweigh the increased financial outlay. Assuming, then, that environmental assessments will continue to be conducted in developing areas, the following are some recommendations for further work in the field.

Information and Training

It is vital that technologists and decision-makers be informed relative to what EIA is, what it is meant to do, and what its limitations are. As long as the perception of EIA is based on hearsay or prejudice, there will be misunderstanding and controversy. Instead of this, work is required to produce a clear understanding of the EIA process by all concerned.

In addition to informing as discussed in the last paragraph, it is also necessary to train technologists to conduct environmental studies in the third world. This training should address the concept of EIA as well as the methods that are available at each step in the assessment. It is recognized that many developing countries will be unable to train sufficient technologists to meet their needs. Perhaps the development of regional pools of experts is a viable solution to this problem.

Local Values

A great deal of work is necessary in order to adapt existing scaling and weighting checklists to reflect the values in different regions and countries. An example of the sort of work which is recommended here is the environmental evaluation system which was developed for Thailand (Lohani and Kan, 1981).

Data Banks

The final recommendation concerns the collection, storage and retrieval of data. It is unlikely that the developing countries will be able to afford extensive monitoring programs at this time. However, three things can be done to optimize the data that does exist. First, whatever data is available can be cataloged. Second, duplication of efforts can be avoided if previous studies are reviewed before new ones are undertaken. And finally, pooling of data on a regional basis will reduce the cost of data handling and also permit the use of surrogate techniques in estimation of impacts.

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APPENDIX A

INDUSTRIALIZED AND DEVELOPING NATIONS

APPENDIX A

INDUSTRIALIZED AND DEVELOPING NATIONS

Introduction

Because no clear definitions of the terms "developing countries" or "third world nations" were found in the literature reviewed, it was necessary to assemble lists of developing and industrialized nations for this project. In this Appendix, the details of how these lists were assembled are presented. From the membership of the United Nations (UN, 1981) and the World Bank Atlas (World Bank, 1980b), a total of 184 separate political units were identified. In the next three sections, economic, social and political indictors for many of these countries are presented. Unfortunately data on each indicator was not available for all countries. The penultimate section contains the actual list of industrialized and developing countries, and the last section addresses the languages spoken in those third world nations to which the international questionnaire was sent.

The primary basis used to categorize nations for this project is the listing of nations in five previous studies. These are the membership list of the UN's Group of 77, the World Bank's classifications, the membership lists of the International Development Association, J. and M. McHales' book "Basic Human Needs", and M.I.

Muiga's doctoral dissertation. Each of these is described in detail in the final section of this Appendix. In the majority of cases, there was general agreement among these five classifications as to the status of any particular nation. Further, that status was reflected in the economic, social and political indicators for that country. Where such a consensus existed, that was accepted as the classification of the country for this study. In some cases, a country's status for this study could not be based on the previous classifications. This situation arose in one of two instances: either there was disagreement; or the country was only included in two or less of the previous classifications. In either case, the status of the country in question was determined based on its economic, social and political indicators. There were a few cases which could not be classified based on the prevous studies, and for which indicators were unavailable. The status of each of these countries was decided upon based on the general description given in the 1981 Colliers Encyclopedia.

Generally, in deciding upon a country's classification, the economic indicators are the most important of the sets of indicators used. These will be presented and discussed in the next section.

Economic Indicators of Development

Three economic indicators are listed in Table A.1. These are the gross national product (GNP) per capita in 1978, the average annual rate of growth of GNP per capita for the period 1970 to 1978, and the average annual rate of inflation for the period 1970 to 1978. These indicators were chosen for two reasons. First, they are commonly used

TABLE A.1: ECONOMIC AND SOCIAL INDICATORS

REFERENCES: WORLD BANK (1980a and 1980b)
U.S. Dept. of State (1975 and 1981)

Country	GNP per capita		Average Annual Rate of Inflation (%) 1970-78	Life Expectancy at Birth, in years (1978)	Daily Calorie Supply per Capita, as % of req'd. (1977)	Adult Literacy Rate (%) (1975)
	1978 in US Dollars	Average Annual % Growth, 1970-78				
AFRICA AND THE MIDDLE EAST						
Algeria	1,450	2.6	13.4	56	99	37
Angola	420	-10.5	22.0	41	91	12
Bahrain	4,060	-1.4	-	65	-	20
Benin	220	1.4	7.4	46	98	11
Botswana	660	13.2	-	48	-	35
Burundi	160	1.3	10.1	45	97	25
Cameroon	490	2.8	9.8	46	89	65
Cape Verde Islands	260	-	-	60	-	-
Central African Rep.	270	1.0	9.0	46	99	10
Chad	150	-0.6	7.4	43	74	15
Comoros	200	-5.3	-	46	-	-
Congo	580	0.2	10.6	46	103	50
Djibouti	410	-1.2	-	45	-	10
Egypt	420	6.3	7.0	54	109	44
Equatorial Guinea	240	-1.5	-	-	-	20
Ethiopia	110	-0.1	4.0	39	75	10
Gabon	3,370	8.6	-	44	-	12
Gambia	180	2.9	-	41	-	10
Ghana	380	-3.0	35.9	48	86	30
Guinea	260	0.8	6.4	43	84	10
Guinea-Bissau	160	2.9	-	41	-	4
Iran	2,160	7.9	23.7	52	89	50
Iraq	1,850	7.7	-	55	130	30
Israel	3,730	1.6	31.0	72	122	88
Ivory Coast	950	0.9	13.9	46	105	20
Jordan	1,100	7.0	-	56	62	70
Kenya	350	2.5	12.0	53	88	40
Kuwait	15,970	0.6	19.8	69	-	60
Lebanon	730	-	-	65	101	86
Lesotho	300	9.3	12.2	50	99	55
Liberia	460	0.2	9.7	48	104	30
Libya	7,210	-2.6	20.7	55	126	50
Madagascar	250	-2.7	9.6	46	115	50
Malawi	180	3.1	9.1	46	90	25
Mali	130	1.8	7.8	42	90	10
Mauritania	270	-0.6	10.4	42	86	17
Mauritius	920	6.9	-	67	-	80
Morocco	680	3.9	7.1	55	105	28
Mozambique	240	-5.5	10.9	46	81	20
Namibia	1,160	0.6	-			-
Niger	240	-0.6	10.7	42	91	8
Nigeria	600	4.4	18.2	48	83	25

TABLE A.1 (continued)

Country	GNP per capita 1978 in US Dollars	GNP per capita Average Annual % Growth, 1970-78	Average Annual Rate of Inflation (%)1970-78	Life Expectancy at Birth, in years (1978)	Daily Calorie Supply per Capita, as % of req'd. (1977)	Adult Literacy Rate (%) (1975)
Oman	2,790	3.7	-	47	-	5
Qatar	15,050	-2.5	-	48	-	20
Reunion	3,740	-1.0	-	-	-	-
Rwanda	190	1.4	14.7	46	98	23
Sao Tome & Principe	410	-	-	-	-	10
Saudi Arabia	6,590	4.9	28.4	53	88	25
Senegal	360	-0.3	8.0	42	95	10
Seychelles	1,250	3.9	-	-	-	60
Sierra Leone	230	-1.3	10.8	46	93	15
Somalia	130	-0.5	10.7	43	88	60
South Africa	1,580	0.7	11.7	60	116	85
Sudan	340	2.6	7.4	46	93	20
Swaziland	580	4.8	-	46	-	65
Syria	960	6.0	12.7	57	108	53
Tanzania	240	1.7	12.3	51	89	66
Togo	320	1.7	7.4	46	90	18
Tunisia	990	5.7	7.1	57	112	55
Uganda	280	-2.8	27.3	53	91	25
Upper Volta	160	-1.0	9.6	42	79	5
United Arab Emirates	15,020	-5.6	-	48	-	(Low)
Yemen Arab Republic	410	-	-	39	91	13
Yemen Peoples Rep.	450	12.7	-	44	81	27
Zaire	240	-2.2	26.2	46	104	15
Zambia	510	-0.9	5.7	48	87	39
Zimbabwe	480	-1.0	7.6	54	108	30
THE AMERICAS						
Antigua	1,000	-3.1	-	-	-	-
Argentina	2,030	1.5	120.4	71	125	94
Bahamas	2,320	-6.4	-	69	-	85
Barbados	2,080	2.1	-	71	-	99
Belize	900	5.0	-	60	-	75
Bermuda	8,620	1.4	-	69	-	98
Bolivia	510	3.1	22.7	52	83	63
Brazil	1,510	6.0	30.3	62	107	76
Canada	8,670	3.0	9.4	74	127	98
Chile	1,470	2.1	242.6	67	109	88
Colombia	900	3.6	21.7	62	102	81
Costa Rica	1,610	3.3	15.7	70	114	90
Cuba	1,270	4.7	-	72	118	96
Dominica	470	-3.4	-	-	-	-
Dominican Republic	900	4.2	8.6	60	93	67
Ecuador	950	5.6	14.8	60	92	74
El Salvador	640	2.2	10.3	63	90	62
French Guiana	2,400	0.3	-	-	-	73
Grenada	570	-1.8	-	69	-	-
Guadeloupe	2,930	3.1	-	-	-	90

TABLE A.1 (continued)

Country	GNP per capita 1978 in US Dollars	GNP per capita Average Annual % Growth, 1970-78	Average Annual Rate of Inflation (%)1970-78	Life Expectancy At Birth, in years (1978)	Daily Caloric Supply per Capita, as % of req'd. (1977)	Adult Literacy Rate (%) (1975)
Guatemala	930	3.3	10.8	57	98	47
Guyana	560	-0.2	-	67	-	86
Haiti	240	2.2	12.2	51	93	23
Honduras	480	0.4	8.0	57	89	57
Jamaica	1,190	-1.4	16.9	70	119	86
Martinique	4,180	6.2	-	-	-	99
Mexico	1,400	1.3	17.5	65	114	76
Nicaragua	840	1.7	11.0	55	109	57
Nederlands Antilles	3,170	0.3	-	-	-	80
Panama	1,260	0.5	7.5	70	101	78
Paraguay	9[illegible]0	4.5	12.3	63	122	81
Peru	680	0.3	22.2	56	97	72
Puerto Rico	2,650	0.3	-	-	-	-
St. Kitts-Nevis	700	1.5	-	-	-	-
St. Lucia	730	2.3	-	-	-	-
St. Vincent	450	-1.8	-	-	-	-
Suriname	2,180	4.7	-	68	111	73
Trinidad and Tobago	3,010	2.4	21.3	70	135	95
U.S.A.	9,770	2.3	6.8	73	-	99
Uruguay	1,790	1.8	65.6	71	114	94
Venezuela	2,850	3.1	11.1	66	99	82
Virgin Islands (U.S.)	5,100	-3.3	-	-	-	-
<u>ASIA AND THE PACIFIC</u>						
Afghanistan	160	2.7	4.4	42	89	12
Australia	8,060	1.5	12.8	73	129	100
American Samoa	7,400	7.0	-	-	-	-
Bangladesh	90	-0.2	17.9	47	78	26
Bhutan	80	-0.2	-	41	88	5
Brunei	9,220	4.9	-	-	-	-
Burma	140	1.7	13.7	53	106	67
China	230	3.7	-	70	105	40
Fiji	1,490	2.0	-	71	-	85
French Polynesia	5,550	2.8	-	-	-	-
Guam	6,950	5.2	-	-	-	-
Hong Kong	3,340	6.9	7.7	72	126	90
India	180	1.6	8.2	51	91	36
Indonesia	340	5.3	20.0	47	105	62
Japan	7,700	7.8	9.6	76	126	99
Kampuchea	-	-	-	-	78	85
Kiribati	830	4.4	-	-	-	-
Korea, North	1,000	3.8	-	63	121	90
Korea, South	1,310	8.1	19.3	63	119	93
Laos	90	-	-	42	94	20
Macao	1,480	16.0	-	-	-	100
Malaysia	1,150	4.8	7.2	67	117	60
Maldives	170	-2.1	-	47	-	-

TABLE A.1(continued)

Country	GNP per capita 1978 in US Dollars	GNP per capita Average Annual % Growth, 1970-78	Average Annual Rate of Inflation (%)1970-78	Life Expectancy at Birth, in years (1978)	Daily Calorie Supply per Capita, as % of req'd. (1977)	Adult Literacy Rate (%) (1975)
Mongolia	700	3.1	-	63	104	100
Nepal	120	0.3	9.1	43	91	19
New Caledonia	770	-4.9	-	-	-	-
New Zealand	5,530	0.9	11.0	73	127	99
Pakistan	240	1.5	14.6	52	99	21
Papua - New Guinea	620	0.2	8.8	50	85	32
Philippines	530	3.7	13.4	60	97	87
Singapore	3,260	6.6	6.1	70	134	75
Solomon Islands	430	-	-	46	-	-
Sri Lanka	200	1.9	11.8	69	96	78
Taiwan	1,400	6.6	10.3	72	120	82
Thailand	530	4.5	9.1	61	105	84
Tonga	830	1.2	-	-	-	95
U.S. Trust of Pac. Is.	1,230	1.5	-	-	-	-
Vanuatu	530	1.9	-	-	-	-
Vietnam	170	-	-	62	83	87
Western Samoa	280	-	19	68	-	90
<u>EUROPE</u>						
Albania	740	4.2	-	69	113	70
Austria	7,520	3.6	7.6	72	134	99
Belgium	9,770	3.0	8.6	72	136	99
Bulgaria	3,210	5.7	-	72	144	95
Cyprus	2,580	1.4	-	72	-	82
Czechoslovakia	4,730	4.3	-	70	139	100
Denmark	10,580	2.1	9.8	74	127	99
Finland	7,160	2.2	13.2	72	114	100
France	8,880	4.0	9.3	73	136	99
Germany, East	5,670	4.8	-	72	127	90
Germany, West	10,300	2.4	5.9	72	139	99
Gibraltar	3,840	5.0	-	-	-	-
Greece	3,450	3.8	13.8	73	136	85
Greenland	7,280	5.5	-	-	-	-
Hungary	3,480	5.1	-	70	134	98
Iceland	9,510	3.3	-	75	-	99
Ireland	3,810	2.3	14.7	73	141	98
Italy	4,600	2.0	14.0	73	136	98
Luxemburg	11,320	4.1	-	72	-	98
Malta	2,310	11.2	-	71	-	88
Netherlands	9,200	4.3	8.8	74	124	99
Norway	10,710	3.9	8.6	75	118	99
Poland	3,650	5.9	-	71	140	98
Portugal	1,940	2.0	15.2	69	126	70
Rumania	1,650	9.6	-	70	130	98
Spain	3,960	3.1	15.0	73	128	97
Sweden	10,540	1.1	9.3	75	120	99
Switzerland	12,990	0.0	6.6	74	130	99

TABLE A.1 (continued)

Country	GNP per capita: 1978 in US Dollars	GNP per capita: Average Annual % Growth, 1970-78	Average Annual Rate of Inflation (%) 1970-78	Life Expectancy at Birth, in years (1978)	Daily Calorie Supply per Capita, as % or req'd. (1977)	Adult Literacy Rate (%) (1975)
Turkey	1,250	4.1	21.5	61	115	60
United Kingdom	5,720	1.9	14.1	73	132	99
U.S.S.R.	3,710	4.3	-	70	135	99
Yugoslavia	2,100	5.0	17.3	70	136	95

as measures of development. Second, data was available for most of the countries being categorized. It should be noted that the growth of GNP per capita listed is real growth, i.e., growth after correction for inflation.

Both GNP per capita and GNP per capita growth could be very misleading if used as sole indicators of development. This is mainly because GNP says nothing about the distribution of income within a country. Thus, a given value of GNP per capita might indicate any situation bounded by three extremes. First, it may be that the national income is equitably distributed to the whole country. Alternatively, the income may be concentrated in a small, rich elite, while the rest of the country is poor. Finally, the income may represent a resource exploited by a non-national company, from which the country derives almost no benefit. Unfortunately, the GNP does not indicate which is actually the case (Shams, 1976).

In spite of the above comments, both GNP per capita and growth rate of GNP per capita can be useful indicators of development when used in conjunction with other data. The same holds true for the inflation rate. As a sole indicator, it would be misleading. However, viewed in conjunction with other data it can be used to evaluate a country's level of development.

Several general trends are noted here, and will be used later on when the lists of developing and industrialized countries are assembled. The first is that the developing countries of the world have lower GNP per capita than the industrialized ones. There are exceptions. Several oil-producing countries have extremely high GNP per capita which are not truly reflective of the country's development. Also, there is distortion when the population of a country is very small. In these cases, even though the GNP per capita ratio is large, the total GNP is still too small to support meaningful development.

The second comment relates to the rate of growth of GNP per capita. Over the period 1970 to 1978, the average rate of growth was higher in industrialized nations than in developing countries. It should be noted, however, that this relationship was not uniform over the period. The gap has been closing, and by the end of the period several developing areas were achieving a greater rate of growth than their industrialized counterparts (World Bank, 1981). One distortion arises where a nation started the period with an extremely low GNP per capita. In this case, the growth rate appears to be very healthy, but the actual GNP per capita at the end of the period is still low. Another distortion relates to population growth. In several countries, the percentage increase in population has far outpaced the percentage increase in total GNP. Thus, a decrease in GNP per capita is recorded.

The final comment is that the rate of inflation in the third world has generally been higher than in the developed world. This results from the simple fact that inflation can be imported. Many developing countries import heavily to satisfy their need for food, fuels and consumer products. In these cases, the inflation of the supplier is imported, and aggravated by local inflation (Szekely, 1976).

Traditionally, economic data have been used as the prime indicators of development. However, a country's level of development is reflected in its social and political institutions as well as its economy. In the next section, three social indicators of development will be discussed.

Social Indicators of Development

The three social indicators listed in Table A.1 are life expectancy at birth (in 1978), daily calorie supply per capita as a percentage of requirement (in 1977), and adult literacy rate (in 1975). As with the economic indicators these were chosen because they are commonly used measures of development, and because data was available for many of the countries being categorized. As in the previous section, general trends are noted here, and will be applied later on.

Life expectancy at birth is a function of several other factors. Foremost among these are the availability of health care, nutrition, safe water and clean air. In many developing countries, life expectancy is reduced by inadequate health services and deficient or unbalanced diet (El Gamal, 1979; Mahler, 1979; and Quarcoopome, 1980). As a country develops, these problems are gradually solved. Thus, life expectancy in industrialized nations is generally higher than in developing countries.

Daily calorie supply refers to the amount of food available, on the average, to members of a country's population. Like GNP per capita, daily calorie supply per capita is an indicator which must be viewed with caution. The reason is that this is also a blanket ratio which gives no indication of distribution. Thus, a given value of daily calorie supply per capita may indicate an equitable distribution. Or it may signify gluttony by part of the population and starvation of the rest. In general, though, daily calorie supply in the industrialized world is greater than in the developing countries. This is because most of the developed countries have adopted large-scale, high production agricultural techniques, and hence many are food exporters. In the third world, subsistence farming is still the order of the day, and many developing countries import food. Ironically, some developing countries practice large-scale farming for non-food or export crops, but are unable to satisfy their own food needs. Such is the case of sugar in the Caribbean island-nations (Williams, 1976).

Adult literacy rate is a measure of the extent to which the human potential of a country is being harnessed. The attitude of the colonial powers to education in the colonies was mentioned in Chapter III. The result is that adult literacy rates in the ex-colonies is lower than in the metropolitan countries. Additionally, there is some variation within the third world. For reasons best known to themselves, the imperial powers favored some colonies more than others. Thus, the ex-colonies in the New World boast a generally higher level of literacy than their African counterparts.

The final set of indicators used to categorize the countries of the world are political. These are discussed in the next section, following the same format used in this section and the last.

Political Indicators of Development

Table A.2 lists the current status of the world's dependent areas. For independent states, the year of independence and status before independence are listed. Consideration was given to using each

TABLE A.2: POLITICAL INDICATORS

Ref: U.S. Dept. of State (1975 and 1981)
United Nations (1981)

Country	Comment (1) (Status before Independence)	Year Of Indep.
AFRICA AND THE MIDDLE EAST		
Algeria	(French colony)	1962
Angola	(Port. colony)	1976
Bahrain	(Brit. protectorate)	1971
Benin	(French colony of Dahomey)	1960
Botswana	(Brit. colony of Bechuanaland)	1966
Burundi	(U.N. trust territory of Urundi)	1962
Cameroon	(U.N. trust territory)	1960
Canary Islands	Spanish territory	-
Cape Verde Island	(Port. overseas province)	1975
Central African Rep.	(French Overseas territory of Ubangi-Shari)	1960
Chad	(French overseas territory)	1960
Comoros	(French overseas territory)	1975
Congo	(French overseas territory)	1960
Djibouti	(French territory of Afars and Issas)	1977
Egypt	(Brit. protectorate)	1922
Equatorial Guinea	(Span. overseas province)	1968
Ethiopia	Ancient nation, pre-dating the Christian Era	(2)
Gabon	(French overseas territory)	1960
Gambia	(Brit. colony)	1965
Ghana	(Brit. colony of the Gold Coast)	1957
Guinea	(French colony)	1957
Guinea-Bissau	(Port. colony of Portugese Guinea)	1974
Iran	Ancient nation of Persia	(2)
Iraq	(Brit. mandate)	1932
Israel	(Brit. mandate of Palestine)	1948
Ivory Coast	(French overseas territory)	1960
Jordan	(Brit. mandate of Transjordan)	1946
Kenya	(Brit. colony)	1963
Kuwait	(Brit. protectorate)	1961
Lebanon	(French mandate)	1943
Lesotho	(Brit. colony of Basutoland)	1966
Liberia	(Land purchased by U.S.)	1874
Libya	(Brit. and French administration)	1951
Madagascar	(French overseas territory)	1960
Malawi	(Brit. colony of Nyasaland)	1964
Mali	(French overseas territory of Soudan)	1960
Mauritania	(French overseas territory)	1960
Mauritius	(Brit. colony)	1968
Morocco	(French and Span protectorate)	1956
Mozambique	(Port. overseas province)	1975
Namibia	Under disputed South African Administration	-
Niger	(French overseas territory)	1960
Nigeria	(Brit. colony)	1960
Oman	(Port. colony of Muscat and Oman)	1650
Qatar	(Brit. protectorate)	1971
Reunion	French overseas department	-
Rwanda	(French overseas territory)	1962
Sao Tome & Principe	(Port, overseas province)	1975
Saudi Arabia	Modern state unified in 1932	(2)
Senegal	(French overseas territory)	1960
Seychelles	(Brit. colony)	1976
Sierra Leone	(Brit. Protectorate)	1961

TABLE A.2 (continued)

Country	Comment (1) (Status before Independence)	Year Of Indep.
Somalia	(Brit. colony and U.N. trust territory of Somaliland)	1960
South Africa	(2 republics plus 2 Brit. colonies)	1910
Sudan	(Brit.-Egyptian administration)	1956
Swaziland	(Brit. colony)	1968
Syria	(French mandate)	1946
Tanzania	(U.N. trust territory of Tanganyika and Brit. colony of Zanzibar)	1961
Togo	(U.N. trust territory)	1960
Tunisia	(French protectorate)	1956
Uganda	(Brit. protectorate)	1962
Upper Volta	(French overseas territory)	1960
United Arab Emirates	(Brit. protectorate)	1971
Yemen Arab Republic	(Turkish colony)	1918
Yemen Peoples Rep.	(Brit. colony)	1967
Zaire	(Belgian colony)	1960
Zambia	(Brit. colony of Northern Rhodesia)	1964
Zimbabwe	(Brit. colony of Southern Rhodesia)	1980
THE AMERICAS		
Antigua	(Brit. associated state)	1981
Argentina	(Span. colony of Rio Plata)	1816
Bahamas	(Brit. colony)	1973
Barbados	(Brit. colony)	1966
Belize	(Brit. colony)	1981
Bermuda	Brit. colony	-
Bolivia	(Span. colony)	1825
Brazil	(Port. colony)	1822

Country	Comment	Indep.
British West Indies	Brit. colonies (5)	-
Canada	(Brit. colony)	1867
Chile	(Span. colony)	1818
Colombia	(Span. colony)	1813
Costa Rica	(Span. colony)	1821
Cuba	(Span. colony)	1902
Dominica	(Brit. associated state)	1978
Dominican Republic	(Span. colony)	1865
Ecuador	(Span. colony)	1822
El Salvador	(Span. colony)	1821
Falkland Islands	Brit. colony	-
French Guiana	French overseas Department	-
Grenada	(Brit. associated state)	1974
Guadeloupe	French overseas Department	-
Guatemala	(Span. colony)	1821
Guyana	(Brit. colony)	1966
Haiti	(French colony)	1804
Honduras	(Span. colony)	1838
Jamaica	(Brit. colony)	1962
Martinique	French overseas Department	-
Mexico	(Span. colony)	1810
Nicaragua	(Span. colony)	1838
Nederlands Antilles	Dutch territory	-
Panama	(Part of Confederation of Colombia)	1903
Paraguay	(Span. colony)	1811
Peru	(Span. colony)	1821
Puerto Rico	Commonwealth associated with U.S.	-
St. Kitts-Nevis	Brit. associated state	-
St. Lucia	(Brit. associated state)	1979

TABLE A.2(continued)

Country	Comment (1) (Status before Independence)	Year Of Indep.
St. Vincent	(Brit. associated state)	1980
Surinam	(Dutch colony)	1975
Trinidad and Tobago	(Brit. colony)	1962
U.S.A.	(Brit. colony)	1776
Uruguay	(Span.-Port. disputed colony)	1828
Venezuela	(Span. colony)	1821
Virgin Islands (U.S.)	U.S. organized territory	-
<u>ASIA AND THE PACIFIC</u>		
Afghanistan	(Brit. colony)	1919
Australia	(Self-governing federation under Brit.)	1942
American Samoa	U.S. organized territory	-
Bangladesh	(East Pakistan)	1971
Bhutan	Ancient kingdom, formerly under Brit. protection	(2)
Brunei	Brit. protected state	-
Burma	(Brit. colony)	1948
China	Ancient empire	(2)
	(Brit. colony)	1970
French Polynesia	French overseas territory	-
Guam	U.S. organized territory	-
Hong Kong	Brit. colony	-
India	(Brit. colony)	1947
Indonesia	(Dutch colony)	1945
Japan	Ancient kingdom	(2)
Kampuchea	(French protectorate)	1953
Kiribati	(Brit. colony of Gilbert Islands)	1978
Country	**Comment**	**Indep.**
Korea, North	(Annexed by Japan)	(2)
Korea, South	(Annexed by Japan)	(2)
Laos	(French colony)	1953
Macao	Port. overseas province	-
Malaysia	(Brit. protectorate)	1957
Maldives	(Brit. protectorate)	1965
Mongolia	Ancient kingdom and empire	(2)
Nepal	Ancient kingdom	(2)
New Caledonia	French overseas territory	-
New Zealand	(Self-governing under Brit.)	1947
Pakistan	(Brit. colony)	1947
Papua - New Guinea	(U.N. trust territory)	1975
Philippines	(U.S. administration)	1946
Portugese Timor	Port. overseas province	-
Singapore	(Brit. colony)	1965
Solomon Islands	(Brit. colony)	1978
Sri Lanka	(Brit. colony)	1948
Taiwan	(Part of China)	1949
Thailand	Ancient kingdom	(2)
Tonga	(Brit. protectorate)	1970
Tuvalu	(Brit. colony of Ellice Islands)	1978
U.S. Trust of Pac. Is.	U.N. trust territory	-
Vanuatu	(Brit. colony of New Hebrides)	1980
Vietnam	(French colonies of North and South Vietnam)	1954
Western Samoa	(U.N. trust territory)	1962

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TABLE A.2 (continued)

Country	Comment (1) (Status before Independence)	Year Of Indep.
EUROPE		
Albania	(3)	(2)
Austria	(3)	(2)
Belgium	(annexed by France)	1830
Bulgaria	(3)	(2)
Cyprus	(Brit. colony)	1960
Czechoslovakia	(ruled by Austria and Hungary)	1918
Denmark	(3)	(2)
Finland	(Russian colony)	1918
France	(3)	(2)
Germany, East	(3)	(2)
Germany, West	(3)	(2)
Gibraltar	British colony	-
Greece	(Part of Ottoman Empire)	1833
Greenland	Danish territory	-
Hungary	(3)	(2)
Iceland	(Danish colony)	1944
Ireland	(Self-governing under Brit.)	1921
Italy	(3)	(2)
Luxemburg	(Dutch controlled)	1867
Malta	(British colony)	1964
Netherlands	(3)	(2)
Norway	(annexed by Sweden)	1905
Poland	(3)	(2)
Portugal	(3)	(2)

Country	Comment	Indep.
Rumania	(3)	(2)
Spain	(3)	(2)
Sweden	(3)	(2)
Switzerland	(German colony)	1291
Turkey	(center of Ottoman Empire)	1923
United Kingdom	(3)	(2)
U.S.S.R.	(3)	(2)
Yugoslavia	(Austro-Hungarian colony)	1918

NOTES:

(1) Comments give current status of dependent territories. Bracketed comments give status of independent nations prior to independence.

(2) Year of independence not listed in cited references.

(3) Because of the great fluidity of European boundries over the centuries, pre-independence status of European nations are not listed where they are not clear.

(4) Brit. = British, Port. = Portugese, and Span. = Spanish.

(5) British West Indies includes Anguilla, Cayman Islands and Monserrat.

country's political system as an indicator of development, but this was abandoned for three reasons. The first is non-uniformity of practice among states professing the same system in theory. Secondly, many countries have changed their political system in recent years, some several times. In these cases, the level of development does not reflect the results of any one system. Finally, contrary to propaganda, there is no evidence that one political system results in more rapid development than any other.

Just one trend is noted from the political indicators. This is that the newer nations and the still dependent areas tend to be developing countries. The older nations, and especially the ex-colonial powers, are generally industrialized. The reasons for this are found in the economic structure of the empires, which was discussed in the first section of Chapter III.

This section and the two previous ones have been devoted to presenting and discussing economic, social and political indicators of development. In the next section, each of the 184 political units will be classified as either developing or industrialized.

Listing of Nations

In the introduction to this Appendix, five previous classifications of nations are introduced. The strengths and limitations of each are discussed in this section. These five lists are then used, in conjunction with the indicators presented previously, to derive a classification for this study. The classification of specific nations is further explained, and additional information is presented, where necessary.

Previous Studies

When it became apparent that no clear definition of "developing country" was available in the literature reviewed, several organizations were contacted in the hope that one or several had definitions which could be used. Letters were sent to the United Nations Environment Program (UNEP), the World Health Organization (WHO), the World Bank, the Organization for Economic Co-operation and Development (OECD, France), the Center for Developing-Area Studies (McGill University, Canada), and the Center for Integrative Studies (CIS, State University of New York, Buffalo). None of these was able to provide a definition of the term nor a list of criteria to differentiate between developing and industrialized countries. However, three organizations suggested lists of developing and industrialized countries which could be used. J.C. Faby of UNEP suggested that the membership of the UN's "Group of 77" could be used as a list of developing countries. R.J.V. Goodland of the World Bank provided their classification of countries as well as the membership lists of the International Development Association. M.C. McHale of CIS cited the list of nations contained in the book "Basic Human Needs" (McHale and McHale, 1977). These four lists and one other study were used to develop the classification used in this study.

The "Group of 77" (UN, 1980) is a caucus within the UN which seeks the interests of the developing nations. The Group is fairly representative of the third world, with the exception of the Eastern Block countries. For political reasons, some satellites of the USSR and China have refrained from membership of the Group of 77. Another set of countries which are not represented by the Group are the dependent states. This is because the Group consists of UN members, and all members of the UN are independent.

The World Bank classifies nations into five groups, based mainly on economic status. The low income nations are the poorest countries, those with a GNP per capita of less than US $390. These countries are all developing. The middle income countries have GNP per capita between US $390 and US $3500. The majority of these are developing, but a few are industrialized. The group of capitalist nations with GNP per capita above US $3500 are termed industrialized by the World Bank, and also in this study. The centrally planned economies are grouped together by the World Bank, regardless of GNP per capita. Some of these are developing, and others are industrialized. Finally, the capital-surplus oil exporting countries are grouped together. Despite extremely high GNP per capita, the majority of these are developing countries (World Bank, 1980a).

The International Development Association (IDA) is associated with, but legally distinct from, the World Bank. Its members fall into two groups. Part I members are the more affluent nations who provide the major part of the Association's funds. Part II members are the poorer nations, and are the recipients of most of the Association's loans. With very few exceptions, Part I members are industrialized, and Part II members are developing (World Bank, 1981).

McHale and McHale (1977) considered 125 indicators in classifying the world's countries into five groups. They contended that a simple dichotomy into developing and industrialized nations did not adequately describe the distribution of development levels that presently exist. For the present study, countries in the McHales' groups A and B are generally taken to be industrialized. Those in groups, C, D and E are considered developing.

The final list of developed countries considered was that of Muiga (1975). As part of his doctoral research, Muiga sent a questionnaire to water treatment authorities in 63 developing countries. Unlike the previous lists, this one did not attempt to be comprehensive. Therefore, while countries included in Muiga's list are developing, those not on the list are not necessarily industrialized.

Present Study

The 184 countries identified in this study are listed on Table A.3. Each country's classification in each of the previous studies discussed in the last section is indicated. Finally, the classification in the present study is noted. In the majority of cases, there is no disagreement as to a country's classification. Generally, countries falling in groups C, D or E in the McHales' study are also members of the "Group of 77"; are low or middle income countries in the World Bank lists, are Part II members of the IDA, and many were included in Muiga's survey. There are, however, a few cases where there was disagreement. There were, too, cases where data was lacking. Where either was the case, a discussion of that country's classification is presented below.

The Canary Islands are constitutionally a part of the Spanish republic. However, because of their distance from the mainland and

TABLE A.3: INDUSTRIALIZED AND DEVELOPING COUNTRIES

COUNTRY	CLASSIFICATION					
	McHale and McHale (1977)[1]	UN "Group of 77"[2]	World Bank (1980)[3]	IDA (1981)[4]	Muiga (1975)[5]	Present Study
AFRICA AND THE MIDDLE EAST						
Algeria	C	mem	mic	II	Yes	Developing
Angola	E	mem	lic	-	—	Developing
Bahrain	C	mem	cso	-	—	Developing
Benin	E	mem	lic	II	—	Developing
Botswana	D	mem	mic	II	—	Developing
Burundi	E	mem	lic	II	—	Developing
Cameroon	D	mem	mic	II	Yes	Developing
Canary Islands	—	(n-m)	—	-	—	Developing
Cape Verde Island	—	mem	lic	II	—	Developing
Central African Rep.	E	mem	lic	II	Yes	Developing
Chad	E	mem	lic	II	—	Developing
Comoros	—	mem	lic	II	—	Developing
Congo	D	mem	mic	II	—	Developing
Djibouti	—	mem	mic	II	—	Developing
Egypt	C	mem	mic	II	Yes	Developing
Equatorial Guinea	E	mem	lic	II	—	Developing
Ethiopia	E	mem	lic	II	Yes	Developing
Gabon	E	mem	mic	II	Yes	Developing
Gambia	E	mem	lic	II	—	Developing
Ghana	D	mem	mic	II	Yes	Developing
Guinea	E	mem	lic	II	—	Developing
Guinea-Bissau	E	mem	lic	II	—	Developing
Iran	C	mem	cso	II	—	Developing
Iraq	C	mem	cso	II	—	Developing
Israel	B	n-m	mic	II	—	Industrialized
Ivory Coast	D	mem	mic	II	Yes	Developing
Jordan	C	mem	mic	II	Yes	Developing
Kenya	D	mem	lic	II	Yes	Developing
Kuwait	C	mem	cso	I	—	Developing
Lebanon	C	mem	mic	II	Yes	Developing
Lesotho	E	mem	lic	II	—	Developing
Liberia	E	mem	mic	II	Yes	Developing
Libya	C	mem	cso	II	Yes	Developing
Madagascar	D	mem	lic	II	Yes	Developing
Malawi	E	mem	lic	II	Yes	Developing
Mali	E	mem	lic	II	Yes	Developing
Mauritania	E	mem	lic	II	—	Developing
Mauritius	E	mem	mic	II	—	Developing
Morocco	D	mem	mic	II	Yes	Developing
Mozambique	E	mem	lic	-	Yes	Developing
Namibia	—	(n-m)	—	-	—	Developing
Niger	E	mem	lic	II	—	Developing
Nigeria	D	mem	mic	II	Yes	Developing
Oman	C	mem	cso	II	—	Developing
Qatar	C	mem	cso	-	—	Developing
Reunion	C	(n-m)	—	-	—	Developing

TABLE A.3 (continued)

COUNTRY	CLASSIFICATION					
	McHale and McHale (1977)[1]	U.N. "Group of 77"[2]	World Bank (1980)[3]	IDA (1981)[4]	Muiga (1975)[5]	Present Study
Rwanda	E	mem	lic	II	Yes	Developing
Sao Tome & Principe	—	mem	mic	II	—	Developing
Saudi Arabia	—	mem	cso	II	Yes	Developing
Senegal	D	mem	lic	II	—	Developing
Seychelles	—	mem	mic	-	—	Developing
Sierra Leone	D	mem	lic	II	Yes	Developing
Somalia	E	mem	lic	II	Yes	Developing
South Africa	C	(n-m)	mic	I	—	Developing
Sudan	E	mem	lic	II	Yes	Developing
Swaziland	D	mem	mic	II	—	Developing
Syria	C	mem	mic	II	Yes	Developing
Tanzania	E	mem	lic	II	—	Developing
Togo	E	mem	lic	II	—	Developing
Tunisia	D	mem	mic	II	Yes	Developing
Uganda	E	mem	lic	II	Yes	Developing
Upper Volta	E	mem	lic	II	—	Developing
United Arab Emirates	C	mem	cso	-	—	Developing
Yemen Arab Republic	E	mem	mic	II	—	Developing
Yemen Peoples Republic	E	(n-m)	mic	II	—	Developing
Zaire	E	mem	lic	II	Yes	Developing
Zambia	D	mem	mic	II	Yes	Developing
Zimbabwe	C	mem	mic	II	—	Developing
THE AMERICAS						
Antigua	—	(n-m)	—	-	—	Developing
Argentina	B	mem	mic	II	Yes	Developing
Bahamas	C	mem	mic	-	—	Developing
Barbados	C	mem	mic	-	Yes	Developing
Belize	—	(n-m)	—	-	—	Developing
Bermuda	—	(n-m)	—	-	—	Developing
Bolivia	D	mem	mic	II	Yes	Developing
Brazil	C	mem	mic	II	Yes	Developing
British West Indies[6]	—	(n-m)	—	-	—	Developing
Canada	A	n-m	ic	I	—	Industrialized
Chile	C	mem	mic	II	Yes	Developing
Colombia	D	mem	mic	II	Yes	Developing
Costa Rica	C	mem	mic	II	Yes	Developing
Cuba	C	mem	cpe	-	—	Developing
Dominica	—	mem	—	II	—	Developing
Dominican Republic	C	mem	mic	II	—	Developing
Ecuador	D	mem	mic	II	—	Developing
El Salvador	D	mem	mic	II	Yes	Developing
Falkland Islands	—	(n-m)	—	-	—	Developing
French Guiana	—	(n-m)	—	-	—	Developing
Grenada	C	mem	mic	II	—	Developing
Guadeloupe	C	(n-m)	—	-	—	Developing
Guatemala	C	mem	mic	II	Yes	Developing
Guyana	C	mem	mic	II	Yes	Developing
Haiti	E	mem	lic	II	Yes	Developing
Honduras	D	mem	mic	II	—	Developing

TABLE (continued)

COUNTRY	CLASSIFICATION					
	McHale and McHale (1977)[1]	U.N. "Group of 77"[2]	World Bank (1980)[3]	IDA (1981)[4]	Muiga (1975)[5]	Present Study
Jamaica	C	mem	mic	-	Yes	Developing
Martinique	C	(n-m)	—	-	—	Developing
Mexico	B	mem	mic	II	Yes	Developing
Nicaragua	C	mem	mic	II	—	Developing
Nederlands Antilles	C	(n-m)	—	-	—	Developing
Panama	C	mem	mic	II	Yes	Developing
Paraguay	C	mem	mic	II	Yes	Developing
Peru	C	mem	mic	II	Yes	Developing
Puerto Rico	—	(n-m)	—	-	Yes	Developing
St. Kitts-Nevis	—	(n-m)	—	-	—	Developing
St. Lucia	—	mem	—	-	—	Developing
St. Vincent	—	mem	—	-	—	Developing
Surinam	C	mem	mic	-	—	Developing
Trinidad and Tobago	C	mem	mic	II	Yes	Developing
U.S.A.	A	n-m	ic	I	—	Industrialized
Uruguay	C	mem	mic	II	Yes	Developing
Venezuela	C	mem	mic	-	Yes	Developing
Virgin Islands (U.S.)	—	(n-m)	—	-	—	Developing
<u>ASIA AND THE PACIFIC</u>						
Afghanistan	E	mem	lic	II	Yes	Developing
Australia	A	n-m	ic	I	—	Industrialized
American Samoa	—	(n-m)	—	-	—	Developing
Bangladesh	E	mem	lic	II	—	Developing
Bhutan	E	mem	lic	-	—	Developing
Brunei	—	(n-m)	—	-	—	Developing
Burma	D	mem	lic	II	Yes	Developing
China	C	n-m	cpe	-	—	Developing
Fiji	C	mem	mic	II	—	Developing
French Polynesia	—	(n-m)	—	-	—	Developing
Guam	—	(n-m)	—	-	—	Developing
Hong Kong	B	(n-m)	mic	-	—	Industrialized
India	E	mem	lic	II	Yes	Developing
Indonesia	D	mem	lic	II	Yes	Developing
Japan	A	n-m	ic	I	—	Industrialized
Kampuchea	D	mem	lic	II	—	Developing
Kiribati	—	(n-m)	—	-	—	Developing
Korea, North	C	mem	cpe	-	—	Developing
Korea, South	C	mem	mic	II	Yes	Developing
Laos	E	mem	lic	II	Yes	Developing
Macao	—	(n-m)	—	-	—	Developing
Malaysia	C	mem	mic	II	—	Developing
Maldives	—	mem	lic	II	—	Developing
Mongolia	C	n-m	cpe	-	—	Developing
Nepal	E	mem	lic	II	—	Developing
New Calendonia	—	(n-m)	—	-	—	Developing
New Zealand	A	n-m	ic	I	—	Industrialized
Pakistan	D	mem	lic	II	Yes	Developing
Papua - New Guinea	D	mem	mic	II	—	Developing

TABLE A.3(continued)

COUNTRY	CLASSIFICATION					
	McHale and McHale (1977)[1]	U.N. "Group of 77"[2]	World Bank (1980)[3]	IDA (1981)[4]	Muiga (1975)[5]	Present Study
Philippines	D	mem	mic	II	Yes	Developing
Portugese Timor	D	(n-m)	—	-	—	Developing
Singapore	B	mem	mic	-	Yes	Industrialized
Solomon Islands	—	mem	mic	II	—	Developing
Sri Lanka	C	mem	lic	II	—	Developing
Taiwan	C	n-m	mic	II	Yes	Developing
Thailand	C	mem	mic	II	Yes	Developing
Tonga	—	mem	—	-	—	Developing
Tuvalu	—	(n-m)	—	-	—	Developing
U.S. Trust of Pac. Is.	—	(n-m)	—	-	—	Developing
Vanuatu	—	(n-m)	—	-	—	Developing
Vietnam	C	mem	lic	II	Yes	Developing
Western Samoa	—	mem	mic	II	—	Developing
EUROPE						
Albania	C	n-m	cpe	-	—	Developing
Austria	A	n-m	ic	I	—	Industrialized
Belgium	A	n-m	ic	I	—	Industrialized
Bulgaria	B	n-m	cpe	-	—	Industrialized
Cyprus	C	mem	mic	II	Yes	Developing
Czechoslovakia	B	n-m	cpe	-	—	Industrialized
Denmark	A	n-m	ic	I	—	Industrialized
Finland	B	n-m	ic	I	—	Industrialized
France	A	n-m	ic	I	—	Industrialized
Germany, East	A	n-m	cpe	-	—	Industrialized
Germany, West	A	n-m	ic	I	—	Industrialized
Gibraltar	—	(n-m)	—	-	—	Developing
Greece	B	n-m	mic	II	—	Industrialized
Greenland	—	(n-m)	—	-	—	Developing
Hungary	B	n-m	cpe	-	—	Industrialized
Iceland	A	(n-m)	ic	I	—	Industrialized
Ireland	A	n-m	ic	I	—	Industrialized
Italy	B	n-m	ic	I	—	Industrialized
Luxemburg	A	n-m	ic	I	—	Industrialized
Malta	B	mem	mic	-	—	Developing
Netherlands	A	n-m	ic	I	—	Industrialized
Norway	A	n-m	ic	I	—	Industrialized
Poland	B	n-m	cpe	-	—	Industrialized
Portugal	B	n-m	mic	-	—	Industrialized
Rumania	B	n-m	cpe	-	—	Industrialized
Spain	B	n-m	mic	-	—	Industrialized
Sweden	A	n-m	ic	I	—	Industrialized
Switzerland	A	n-m	ic	-	—	Industrialized
Turkey	C	n-m	mic	II	Yes	Developing
United Kingdom	A	n-m	ic	I	—	Industrialized
U.S.S.R.	A	n-m	cpe	-	—	Indistrialized
Yugoslavia	B	mem	mic	-	—	Industrialized

TABLE A.3 (continued)

NOTES:

[1]McHale & McHale: Groups A and B are Industrialized countries; and C, D and E are Developing. (McHale and McHale, 1977)

[2]U.N. "Group of 77": mem = member of group; n-m = non-member of group; (n-m) = non-member of U.N. (United Nations, 1980)

[3]World Bank: mic = middle income country; lic = low income country; ic = industrialized country; cso = capital-surplus oil exporting country; and cpe = centrally planned economy. (World Bank, 1980)

[4]International Development Agency (IDA); I = Part I membership; II = Part II membership. (World Bank, 1981)

[5]Muiga's Questionnaire to Developing Countries: Yes = country included in survey. (Muiga, 1975)

[6]The British West Indies includes the colonies of Anguilla, the Cayman Islands, and Monserrat.

distinct economy, they are not true offshore islands. They are therefore listed separately. The islands are basically agricultural, although petroleum is refined there. The agricultural economy, plus the fact that imports generally exceed exports, classify these islands as developing (Collier's Encyclopedia, Vol. 5, 1981).

Israel would be classified industrialized using the McHales' list and the "Group of 77" membership; but developing using World Bank and IDA criteria. Considering its social and economic indicators, this country more closely resembles the nations of Southwestern Europe than its Middle Eastern neighbors. A significant proportion of the working population is employed in industries and construction, with less than 10% in agriculture. Further, the agriculture is of the large scale, high-production type (Collier's Encyclopedia, Vol. 13, 1981). Hence, Israel is classified industrialized in this study.

Kuwait is a Part I member of the IDA, and boasts an extremely high GNP per capita. Both of these are a result of the country's oil exports. However, the country's social indicators are similar to Jordan's, and Jordan is generally agreed to be a developing country. Thus, although Kuwait is rapidly approaching the status of an industrialized nation, it is considered to be developing for the purposes of this study.

Namibia is a dependent territory under South African administration. This situation is disputed by the UN. The territory is basically agricultural, although the value of diamonds and other minerals produced raises the GNP per capita above that of its neighbors. The territory is classified developing in this study (Collier's Encyclopedia, Vol. 21, 1981).

Reunion is an overseas department of France. This means that it is constitutionally part of the French Republic. Like the Canary Islands, though, it is not a true offshore island. Reunion is an agricultural island, exporting sugar and rum and importing a significant fraction of its food and construction materials. The GNP per capita is higher than most African states, due mainly to a very small population (Collier's Encylcopedia, Vol. 20, 1981). The island is classified developing in this study.

South Africa is best known internationally for it infamous policy of racial segregation. The economy of this country is based on agriculture and mining (Collier's Encyclopedia, Vol. 21, 1981). Its GNP per capita is moderate, as are its social indicators. Like Kuwait, this country is approaching industrialized status but is classified developing in this study.

Antigua is typical of the less populous British New World dependencies. These territories depend on export of agricultural crops and tourism as economic mainstays. Recently, several have become independent. These areas are all less developed than the more populous ex-British islands of Jamaica, Barbados and Trinidad. Since these latter three states are all classified developing, so are Antigua, Anguilla, Belize, Bermuda, the Cayman Islands, Monserrat, St. Kitts-Nevis, St. Lucia and St. Vincent.

Argentina and Mexico would be classified industrialized using the McHales' groupings, but developing by all other lists. Their social and economic indicators are on par with the rest of Latin America, and substantially below the US and Canada. Both countries are therefore classified developing in this study.

The Falkland Islands are the subject of a dispute between Britain and Argentina (Oklahoma Daily, 1982, Sunday Oklahoman, 1982). The economy is agricultural, based upon the rearing of sheep. A significant proportion of food and other necessities are imported (Collier's Encyclopedia, Vol. 9, 1981). The Falklands are classified developing for this study.

American Samoa, Guam and the US Trust of Pacific Islands all come under US administration. The first two boast a high GNP per capita, due to the influence of the US economy. However, the majority of Guam's population practices subsistence agriculture (Collier's Encyclopedia, Vol. 11, 1981) and American Samoa is only slightly more developed (Collier's Encyclopedia, Vol. 20, 1981). The US Trust of Pacific Islands is the least developed of the triad (Collier's Encyclopedia, Vol. 16, 1981). All three territories are therefore classified as developing in this study.

Brunei, situated on the North coast of Borneo, boasts a very high GNP per capita. However, this mainly results from its low population (less than 200,000) and its exports. Main sources of income are forest products, such as hardwood and rubber, and petroleum. The wealth resulting from oil exports has not yet been applied to rapidly develop the area (Collier's Encyclopedia, Vol. 4, 1981). Brunei is therefore classified as developing in this study.

China and Mongolia would be classified developing by the NcHales and the World Bank lists. The fact that they do not belong to the Group of 77 is a reflection of their political system, not their level of development. The social and economic indicators on Table A.1 clearly show that both are developing countries.

French Polynesia, Kiribati, New Caledonia, Tonga, Tuvalu and Vanuatu are all island nations in the Pacific Ocean. None of these six is more developed than the three territories under American administration (American Samoa, Guam and US Trust of Pacific Islands) discussed previously (Colliers Encyclopedia, Vol. 19, 1981). These six Pacific nations are therefore classified as developing in this study.

Hong Kong and Macao are two enclaves on China's South Coast. Both are centered around port facilities, the former originally having served the British empire, and the latter the Portugese. Neither has sufficient land to produce enough food to meet its needs. Both have attempted to develop themselves based on port operations income and industry. The former has been quite successful at this, but the latter has not (Collier's Encyclopedia, Vol. 11 & 15, 1981). This is reflected in the disparity between their GNP per capita. Hong Kong is classsified industrialized in this study, and Macao developing.

Singapore, like Hong Kong, has been able to develop itself using port facilities and light industry as an economic base (US Dept. of State, 1981). Although a member of the Group of 77 and included in Muiga's list, Singapore would be classified as industrialized on the McHales' grouping. Its social and economic indicators are closer to those of Hong Kong, New Zealand, Australia and Japan than to the less developed countries of the Pacific and South-East Asia. Singapore is therefore classified as industrialized in this study.

Albania is a member of McHale's group C, but is not a member of the UN's group of 77. The country has a centrally planned economy. Since its economic indicators are clearly those of a developing country, its non-membership of the group of 77 is a reflection of its political allegiance. This is similar to the cases of China and Mongolia. Albania is therefore classified as developing in this study.

Gibraltar and Malta were two strategic British seaports in the Mediterranean. The former is still a colony, but the latter has gained its independence. Like Hong Kong, Macao and Singapore in the Pacific, they have tried to build their economies around the port operations. Neither has been as successful as Hong Kong and Singapore. Agriculture has not been developed on a large scale in Malta, and Gibraltar does not have much arable land. Both areas depend on tourism for some income (Collier's Encyclopedia, Vol. 11 and 15, 1981). The GNP per capita of Gibralter and Malta are less than the majority of capitalist European nations, and is closer to those of Cypress and Turkey. Both Gibraltar and Malta are therefore classified as developing in this study.

Greece is in the McHale's group B, and is not a member of the Group of 77. However, it is listed as a middle income country by the World Bank and is a part II member of the IDA. The country's economic indicators are close to those of Spain and several Eastern European countries. Greece is therefore classified as industrialized in this study.

Greenland is constitutionally a part of the Danish Kingdom. Geographically, socially and economically, however, it stands apart. This huge island had a population of only 52,000 in 1980, which may account for the rather high GNP per capita on Table A.1. Despite efforts by the Danish government to introduce sheep farming, the mainstay of the population is seal hunting and cod fishing. Some industries have recently been established recently: fish canneries, freezing plants and shipbuilding. However, for the purposes of this study, Greenland is classified as developing.

Turkey is classified developing in all the previous studies except the Group of 77. However, its economic and social indicators are clearly lower than those of other European nations (except Albania). Turkey is therefore classified as developing in this study.

Yugoslavia is in the McHale's group B, and is a middle income country. However, it is a member of the Group of 77. This latter membership results from Yugoslavia's founding membership of the non-aligned movement. The country's social and economic indicators are on par with Portugal and Rumania so it is classified as industrialized in this study.

Language

The classification of nations developed in the last section was put to two uses. First, the developing countries were reviewed to identify common characteristics which would affect the implementation of EIA. This was done in Chapter III. The second use was to determine where the international questionnaire would be sent, as discussed in

Chapter V. The questionnaire was translated into French and Spanish. Thus, it was necessary to consider the languages spoken in each recipient country in order to decide which questionnaire language would be most appropriate. Table A.4 lists the languages spoken in each recipient country, and the questionnaire language. Further discussion of the rationale used is presented in Chapter V.

Table A.4: Questionnaire Languages (ref. U.S. Dept. of State, 1975 and 1981).

Country	Languages Spoken In Country	Questionnaire Language
AFRICA AND THE MIDDLE EAST		
Algeria	Arabic, Berber, French	French
Angola	Portugese (official), African Languages	English
Bahrain	Arabic (official), English, Farsi, Urdu	English
Benin (Dahomey)	French (official)	French
Botswana	English (official), Setswana	English
Burundi	Kirundi (official), French (official), Kiswahili	French
Cameroon	English (official), French (official)	English
Canary Islands	Spanish	Spanish
Central African Rep.	French (official), Shango	French
Chad	French (official), African Languages	French
Congo	French(official), Lingala, Kikongo	French
Djibouti	French (official), Somali, Afar, Arabic	French
Egypt	Arabic, English, French	English
Ethiopia	Amharic (official), Arabic	English
Gambia	English (official), Mandinka, Wolof	English
Ghana	English (official), Akan, Ewe, Ga, Hausa	English
Guinea	French	French
Guinea-Bissau	Portugese (official), Crioulo	English
Iran	Persian, Turki, Arabic, French, English	English
Iraq	Arabic, Kurdish	English
Ivory Coast	French (official)	French
Jordan	Arabic (official), English	English
Kenya	English, Swahili	English
Kuwait	Arabic (official), English	English
Lebanon	Arabic (official, Armenian, French	French
Lesotho	English (official), Sesotho (official)	English
Liberia	English, African Languages	English
Libya	Arabic	English
Madagascar	Malagasy (official), French	French
Malawi	Chichewa, English	English
Mali	French (official), Bambara	French
Mauritius	French, English, Creole, Hindi, Urdu.	English
Morocco	Arabic (official), French	French
Mozambique	Portuguese, African Languages, English	English
Niger	French (official), Hausa, Djerma	French
Nigeria	English (official), Hausa, Ibo, Yoruba	English
Oman	Arabic (official), English, Farsi, Urdu	English
Reunion	French	French
Rwanda	French (official), Kinyarwanda (official), Kiswahili	French
Saudi Arabia	Arabic	English
Senegal	French (official), Wolof, Peuhl, Mandingo	French

Table A.4: (continued)

Country	Languages Spoken In Country	Questionnaire Language
Sierra Leone	English, Kiro, African Languages	English
Somalia	Somali (official), Arabic, English, Italian	English
South Africa	English (official), Afrikaans (official)	English
Sudan	Arabic (official), English	English
Syria	Arabic (official), French, Armenian, Kurdish	English
Tanzania	Swahili, English	English
Togo	French (official), African Languages	French
Tunisia	Arabic (official), French	French
Uganda	English (official), Swahili, Luganda	English
Upper Volta	French (official), More	French
Yemen Arab Republic	Arabic	English
Zaire	French (official), African Languages	French
Zambia	English (official), African Languages	English
<u>THE AMERICAS</u>		
Anguilla	English	English
Argentina	Spanish (official), English, French	Spanish
Bahamas	English (official)	English
Barbados	English	English
Belize	English (official), Spanish	English
Bermuda	English	English
Bolivia	Spanish (official), Aymara, Quechau	Spanish
Brazil	Portugese (official), Spanish	Spanish
Cayman Islands	English	English
Chile	Spanish	Spanish
Colombia	Spanish	Spanish
Costa Rica	Spanish	Spanish
Cuba	Spanish	Spanish
Dominica	English	English
Dominican Republic	Spanish	Spanish
Ecuador	Spanish (official), Quechua	Spanish
El Salvador	Spanish	Spanish
Falkland Islands	English	English
French Guiana	French (official)	French
Grenada	English	English
Guatemala	Spanish (official), Native Dialects	Spanish
Guyana	English	English
Haiti	French (official), Creole	French
Honduras	Spanish	Spanish
Jamaica	English	English
Mexico	Spanish	Spanish
Monserrat	English	English
Nederlands Antilles	Dutch (official), Papiamento, English, Spanish	English
Nicaragua	Spanish, English	Spanish

Table A.4: (continued)

Country	Languages Spoken In Country	Questionnaire Language
Panama	Spanish (official), English	Spanish
Peru	Spanish (official), Quechua, Aymara	Spanish
Puerto Rico	Spanish, English	English
St. Lucia	English	English
St. Vincent	English	English
Surinam	Dutch, English, Taki-Taki	English
Trinidad and Tobago	English	English
Uruguay	Spanish	Spanish
Venezuela	Spanish (official)	Spanish
Virgin Islands (U.S.)	English	English
ASIA AND THE PACIFIC		
American Samoa	English, Samoan	English
Bangladesh	Bangla (official), English	English
Burma	Burmese (official), English	English
China	Standard Chinese (official), Cantonese, Shanghai	English
Fiji	English (official), Fijian, Hindi	English
French Polynesia	French	French
Guam	English	English
India	Hindi, English	English
Indonesia	Indonesian (official), English	English
Kampuchea	Khmer	English

Country	Languages Spoken In Country	Questionnaire Language
Korea, North	Korean	English
Korea, South	Korean	English
Malaysia	Malay, Chinese, English, Tamil	English
Maldives	Divehi, Arabic	English
Mongolia	Khalkha Mongol, Chinese, Russian	English
Nepal	Nepali, Newari	English
New Caledonia	French	French
Pakistan	Urdu (official), English, Punjabi, Sindhi	English
Papua New Guinea	English, Neo-Melanesian	English
Philippines	Philippino, English, Spanish	English
Sri Lanka	Sinhala (official), Tamil, English	English
Taiwan	Standard Chinese (official), Taiwanese	English
Thailand	Thai, English	English
U.S. Trust of Pac. Is.	English	English
Vietnam	Vietnamese, French, English	English
EUROPE		
Albania	Albanian	English
Cyprus	Greek, Turkish, English	English
Greenland	Danish	English
Malta	Maltese, English	English
Turkey	Turkish, Kurdish, Arabic	English

APPENDIX B

STATISTICAL ANALYSES

APPENDIX B

STATISTICAL ANALYSES

Introduction

This appendix contains the input data for each of the statistical tests which were performed, and examples of each type of calculation. Discussion of the results is included in the text of this report, and will not be repeated here. Instead, the relevant chapter and section will be noted at the end of each test included in this appendix.

Goodness-of-Fit Test on Responses

This series of tests was performed to determine whether the distribution of individual responses and countries responding were different from the distribution of developing countries. The test used was the chi-square goodness-of-fit test described in Chapter V. The categories were the McHale's groups C, D and E in the first series of tests, and the World Bank's groups "centrally planned economy (cp)", "low income (li)", "middle income (mi)", and "capital-surplus oil exporters (oe)" in the second. The test was performed for each regional group and then for all developing countries as a group.

The tests based on the McHale's groups are summarized in Table B.1. The first line in each block of this table gives the name of the

Table B.1: Goodness-of-fit of Response to McHale's Distribution of Developing Countries

	Individual Responses C	D	E	Countries Responding C	D	E
	Africa and Middle East:			17	13	32
Obs.:	14	13	15	8	8	11
Exp:	11.34	8.82	21.84	7.29	5.67	14.04
	c=4.75	α<0.1		c=1.68	α>0.25	
	The Americas:			22	5	1
Obs.:	42	4	0	15	2	0
Exp.:	36.34	8.28	1.38	13.43	3.06	0.51
	c=4.47	α=0.1		c=1.06	α>0.25	
	Asia and the Pacific:			10	7	6
Obs.:	22	14	11	6	4	4
Exp.:	20.21	14.10	12.69	6.02	4.20	3.78
	c=0.38	α>0.25		c=.02	α>> 0.25	
	Europe:			4	0	0
Obs.:	5	0	0	3	0	0
Exp.	5	0	0	3	0	0
Note:	response too small to apply test.					
	All Developing Countries:			53	25	39
Obs.:	83	31	26	32	14	15
Exp.:	64.40	29.40	46.20	28.06	12.81	20.13
	c=14.29	α<0.0001		c=1.97	α> 0.25	

region being tested, and the distribution of all developing countries in that region into McHale's groups C, D and E. Thus, of 28 developing countries in the Americas that appeared on the McHale's list, 22 were in Group C, 5 in Group D and 1 in Group E. A total of 45 persons from developing countries in the Americas responded to the questionnaire. Of these, 42 were from Group C countries, and 4 from Group D. These 45 persons were from 17 countries, 15 in Group C and 2 from Group D. These numbers appear in the line "obs", for observed frequencies. Based on the underlying distribution of 22:5:1 for Group C:Group D:Group E, about 36 of the 45 persons would be expected to have come from Group C countries, 8 from Group D and 2 from Group E. Similarly, the expected frequencies (exp) for countries responding were 13 from Group C, 3 from Group D and 1 from Group E. In Table B.1, observed and expected frequencies for individual and country responses are tabulated for four regional groups and for all developing countries. In each case, c and α values are computed. Table B.2 lists the same information, based on the World Bank groups.

For individual responses, the test was

H_0: the distribution of individuals responding is the same as the overall distribution of developing countries.

versus

H_1: the distribution of individuals responding is not the same as the overall distribution of developing countries.

Generally, the results showed that the alternative hypothesis (H_1) would be accepted. From this it can be inferred that the distribution of individuals responding to the questionnaire was somehow biased.

Table B.2: Goodness-of-fit of Response to World Bank Distribution of Developing Countries

	INDIVIDUAL RESPONSES				COUNTRIES RESPONDING			
	cp*	li*	mi*	oe*	cp	li	mi	oe
	Africa and Middle East:				-	31	27	9
obs.	-	16	18	14	-	11	11	6
exp.	-	22.08	19.20	6.72	-	12.88	9.60	3.92
	c=9.64		$\alpha<.025$		c=3.18		$\alpha>0.25$	
	The Americas:				1	1	23	-
obs.	0	0	45	-	0	0	16	-
exp.	1.8	1.8	41.40	-	.64	.64	14.72	-
	c=3.91		$\alpha<0.25$		c=1.39		$\alpha>0.25$	
	Asia and the Pacific:				3	13	9	-
obs.	0	23	24	-	0	7	7	-
exp.	5.64	24.44	16.92	-	1.68	7.28	5.04	-
	c=8.69		$\alpha<0.05$		c=2.45		$\alpha>0.25$	
	Europe:				1	-	3	-
obs.	0	-	5	-	0	-	2	-
exp.	0	-	5	-	0	-	2	-
note:	response was too small to apply test.							
	All Developing Countries:				5	45	62	9
obs.	0	39	92	14	0	18	36	6
exp.	5.80	53.65	73.95	11.60	2.40	22.20	30.60	4.8
	c=14.7		$\alpha<0.01$		c=4.45		$\alpha>0.2$	

*cp=centrally planned economy, li=low income, mi=middle income, oe=capital-surplus oil exporter.

For countries from which responses originated, the test was

H_0: the distribution of countries from which responses were received is the same as the overall distribution of developing countries.

versus

H_1: the distribution of countries from which responses were received is not the same as the overall distribution of developing countries.

In all cases, the results were that the null hypothesis (H_0) would be accepted. Thus, it can reasonably be inferred that the distribution of countries from which responses originated is representative of developing countries. The discussion of the results of these tests is found in Chapter VI under the heading "Distribution of Responses".

Respondents to Questionnaire

A series of chi-square tests for independence (see Chapter V) was run to examine the grouping of respondents by area of employment, level of education, and whether or not they had received specialized environmental training. The data was used in the form of individual responses. The tests were

H_0: the pattern of employment (or educational level, or specialized environmental training) is independent of geographical region and level of development.

versus

H_1: the pattern of employment (or educational level, or specialized environmental training) is dependent upon geographical region and level of development.

<u>Employment</u>: The input data and test results for this set of calculations are shown in Table B.3. In the first calculation, four regions of developing countries were compared with the United States,

Table B.3: Comparison of Respondents by Employment

1. Input Data:

Region or Group	Number of Respondents in each Class		
	Government	Education	Other
(a) Africa and Middle East	18	22	3
(b) Americas (developing)	23	20	16
(c) Asia and the Pacific	27	14	11
(d) Europe (developing)	1	4	1
(e) United States	27	16	24
(f) Canada	7	5	18
(g) Other Industrialized	19	18	13
(h) All Developing	69	60	31
(i) All Industrialized	53	69	55

2. Test Results:

Regions Compared	Test Statistic	α	Decision
a, b, c, d, e, f and g	36.738	0.0002	accept H_1
h and i	12.72	0.0017	accept H_1
a, b and c	10.37	<0.05	accept H_1

Canada and Other Industrialized Countries. The second contingency table compared all developing countries as one group with all industrialized countries as the other. The final comparison was between three groups of developing countries: Africa and the Middle East, Americas, and Asia and the Pacific. The fourth group of developing countries, Europe, was excluded because there were too few responses from these nations. In all three cases, the differences in employment patterns were found to be significant at the $\alpha = 0.05$ level.

Education: The input data and test results for this set of calculations are shown in Table B.4. The three sets of comparisons are the same as were done for Employment. In this case, differences between the "all developing" and "all industrialized" groups were found to be significant at the $\alpha = 0.05$ level. Differences among the seven groups were also found to be significant at that level. However, the differences among the three developing regions were not significant at any reasonable α level. Therefore, it was decided that the pattern of educational level among environmental technologists within the third world is independent of geographical region.

Environmental Training: The input data and test results for this third set of calculations are shown in Table B.5. The three sets of comparisons are the same as were done previously for Employment and Education. Again, differences between the "all developing" and "all industrialized" groups were found to be significant at the $\alpha = 0.05$ level. The test statistic from the comparison of the seven groups lies in a "grey" region. H_0 would be accepted at the $\alpha = 0.05$ level, but H_1 would be accepted at the $\alpha = 0.10$ level. However, the comparison of

Table B.4: Comparison of Respondents by Education

1. Input Data:

Region or Group	Number of Respondents in each Class	
	Bachelor's Degree	Graduate Study
(a) Africa and Middle East	14*	29
(b) America (Developing)	18	41
(c) Asia and the Pacific	13	38
(d) Europe (Developing)	1	5
(e) United States	10	57
(f) Canada	5	26
(g) Other Industrialized	3	47
(h) All Developing	46*	113
(i) All Industrialized	18	130

2. Test Results:

Regions Compared	Test Statistic	α	Decision
a, b, c, d, e, f and g	16.16	0.0129	Accept H_1
h and i	13.06	0.0003	Accept H_1
a, b and c	0.62	>>0.25	Accept H_0

*includes one respondent with no university education.

Table B.5: Comparison of Respondents by Environmental Training

1. Input Data:

Region or Group	Number of Respondents in Each Class: Has had Env. Training	Has not had Env. Training
(a) Africa and Middle East	30	13
(b) America (Developing)	35	24
(c) Asia and the Pacific	28	22
(d) Europe (Developing)	5	1
(e) United States	45	22
(f) Canada	23	7
(g) Other Industrialized	41	9
(h) All Developing	98	60
(i) All Industrialized	109	38

2. Test Results:

Regions Compared	Test Statistic	α	Decision
a, b, c, d, e, f and g	11.59	0.0717	see discussion
h and i	5.13	0.0235	accept H_1
a, b and c	1.99	>0.25	accept H_0

three groups of developing countries leads to a clear acceptance of H_0. As with educational level, the pattern of specialized environmental training among technologists doing environmental work in the developing countries is independent of geographical region.

The discussion of the results of these three sets of calculations is found in Chapter VI, under the heading "Respondents".

The Need for EIA

Questions 7, 8 and 9 of the questionnaire all related to how respondents saw the need for EIA at the present time. Specifically, they addressed the adequacy of present efforts at environmental conservation, the need for EIA, and whether trained technologists were available. The responses were subjected to a series of chi-square tests for independence, as described below. The data was analyzed in the form of individual responses, and the input data and test results are shown in Tables B.6 and B.7. The hypothesis test on this set of questions was

> H_0: Response to the question is independent of geographical region (or level of development, or employment, or education, or environmental training)

versus

> H_1: Response to the question is dependent on geographical region (or level of development, or employment, or education, or environmental training).

Present Efforts: The response to this question was found to be dependent upon each country's level of development. When all developing countries were compared with all industrialized countries, H_1 is accepted at the $\alpha = 0.0001$ level. When a comparison was made

Table B.6: The Need for EIA: Responses by Region and Development Level.

1. INPUT DATA:

Region or Group	Number Giving Each Response: Present Efforts Adequate? YES	NO	Is EIA now Necessary? YES	NO	Are Experts Available? YES	NO
DEVELOPING:						
(a) Africa and Middle East	5	34	42	1	11	29
(b) Americas	6	52	53	3	29	25
(c) Asia and the Pacific	6	43	49	1	12	36
(d) Europe	1	4	5	0	3	3
INDUSTRIALIZED:						
(e) United States	33	26	62	2	53	6
(f) Canada	7	21	30	0	22	7
(g) Other	19	26	44	3	30	18
(h) All Developing	18	133	149	5	55	93
(i) All Industrialized	59	73	136	5	105	31

2. TEST RESULTS:

Comparing	Present Efforts Adequate?	Is EIA now Necessary?	Are Experts Available?
a, b, c, d, e, f and g	$c = 47.84$ $\alpha = 0.0001$ Accept H_1	Chi-square test not applicable	$c = 65.08$ $\alpha = 0.0001$ Accept H_1
h and i	$c = 38.20$ $\alpha = 0.0001$ Accept H_1	Chi-square test not applicable	$c = 46.20$ $\alpha = 0.0001$ Accept H_1
a, b and c	$c = 0.165$ $\alpha = 0.9209$ Accept H_0	Chi-square test not applicable	$c = 11.016$ $\alpha = 0.0041$ Accept H_1

Table B.7: The Need for EIA: Developing Country Responses by Employment, Education and Environmental Training

Employment, Education and Env. Training	Number Giving Each Answer			
	Present Efforts Adequate?		Are Experts Available?	
	YES	NO	YES	NO
1. Employment:				
Government	10	53	19	45
Education	6	52	24	36
Other	2	28	12	12
	$c = 1.86, \alpha = 0.3939$, Accept H_0		$c = 3.43, \alpha = 0.1798$, Accept H_0	
2. Education:				
Bachelor's Degree*	4	38	15	26
Graduate Study	14	94	40	67
	$c = 0.34, \alpha = 0.5606$, Accept H_0		$c = 0.01, \alpha = 0.9283$, Accept H_0	
3. Env. Training				
Has Had	14	78	37	59
Has Not Had	4	53	18	33
	$c = 2.23, \alpha = 0.1355$, Accept H_0		$c = 0.15, \alpha = 0.6985$ Accept H_0	

* Inclues one respondent with no university education.

among four developing and three industrialized areas, the differences are again significant at the $\alpha = 0.0001$ level. However, when the comparison was made among three groups of developing countries, the null hypothesis was readily accepted (see Table B.6). Responses from the developing countries of Europe were excluded from this last comparison, because of the small number received. The responses from developing countries were found to be independent of sector of employment, education or environmental training (see Table B.7).

Need for EIA: There was an overwhelming sentiment among respondents from all countries that EIA is necessary at the present time. Because so few negative responses were received, the chi-square test was not appropriate. However, visual examination of the results showed no obvious trends. The "Yes" ratio ranged from 94% to 100%, regardless of geographical region, level of development, respondents employment, education or environmental training.

Availability of Experts: The response to this question was strongly dependent upon the level of development of the respondent's country. Within the developing countries, the response was dependent upon geographical region (see Table B.6). However, the responses from developing countries were independent of employment, education, and environmental training, all at the $\alpha = 0.15$ level.

Effects of Laws and Practice: A final set of tests were run to determine whether the existance of laws requiring EIA, or the fact that EIAs have been conducted in a country, affected respondent's perception of present efforts. The data and results are shown in Table B.8. Satisfaction with present efforts was found to be dependent upon the

Table B.8: The Adequacy of Present Environmental Efforts

Categories		Are Present Efforts Adequate?	
		YES	NO
1. Does Country Have Laws Requiring EIA?			
	YES	16 (20%)	66 (80%)
	NO	2 (3%)	61 (96%)
		c = 8.74	α = 0.0031
		Accept H_1	
2. Have EIAs Been Conducted?			
	YES	14 (13%)	93 (87%)
	NO	3 (10%)	26 (90%)
		c = 0.157	α = 0.6924
		Accept H_0	

existance of a legal requirement for EIA (at $\alpha = 0.05$ level), but independent of whether or not EIAs have been conducted.

The discussion of the results of these sets of calculations is found in Chapter VI, under the heading "The Need for EIA".

EIA Cost and National Development

Questions 10, 11 and 12 of the international questionnaire related to the respondent's perceptions of the effect of EIA on project cost, national development and project planning. A series of chi-square tests for independence was run to determine whether the effects of level of development, geographical region, respondent's sector of employment, education and specialized environment were significant. The tests were done on the basis of individual responses. In the question about project cost, three choices of answer were presented: increase, no effect, decrease. In the questions about national development and project planning, the choices were enhance, no effect and retard. Because only a few respondents selected the no effect, decrease and retard options, the contingency table became very sparse when each response was tabulated individually. As a result, many cells had expected values less than 5. To correct this, the contingency tables were re-assembled combining the no effect and decrease/retard answers into one category. The hypothesis test was

H_0: Response is independent of level of development (or geographical region, or employment, or education, or environmental training).

versus

H_1: Response is dependent on level of development (or geographical region, or employment, or education, or environmental training).

Cost of EIA

Table B.9 summarizes the responses pertaining to EIA cost. Differences among all seven groups of countries (4 developing and 3 industrialized) were not significant. Differences among the three developing regions were also not significant. Developing Europe was excluded because of low response. However, when all developing countries were tested against all industrialized, the result was in a "grey area". Differences were significant at the $\alpha = 0.10$ level, but not significant at the $\alpha = 0.05$ level. Considering the results of all three tests, it was decided that responses regarding the cost of EIA were independent of level of development and geographical region.

Responses to question 10 from developing countries were independent of the respondent's employment sector and educational level. However, the test on environmental training yielded a statistic in the "grey area". Differences in response between those who had specialized environmental training and those who had not were significant at the $\alpha = 0.10$ level, but not at the $\alpha = 0.05$ level.

EIA and National Development

Perceptions of the effect of EIA on national development are summarized in Table B.10. The answers to this question were found to be dependent upon level of development as well as geographical region. Differences based upon employment sector and environmental training were not significant for responses from developing countries. However,

Table B.9: Cost of EIA

1. INPUT DATA:

REGION OR GROUP	NUMBER GIVING EACH RESPONSE HOW WILL EIA AFFECT PROJECT COST? INCREASE	 NO EFFECT/DECREASE
DEVELOPING:		
a) Africa and Middle East	31	6
b) Americas	37	15
c) Asia and the Pacific	40	8
d) Europe	6	0
INDUSTRIALIZED:		
e) United States	44	15
f) Canada	17	11
g) Other Industrialized	24	14
h) All Developing	114	29
i) All Industrialized	85	36

2. TEST RESULTS:

COMPARING	TEST STATISTIC	α	DECISION
a, b, c, d, e, f and g	8.850	0.1822	Accept H_0
h and i	3.169	0.0751	See discussion
a, b and c	2.964	0.2272	Accept H_0

Table B.9: Continued

CATEGORY	NUMBER GIVING EACH RESPONSE — HOW WILL EIA AFFECT PROJECT COST? INCREASE	NO EFFECT/DECREASE
Employment:		
Government	47	17
Education	43	9
Other	24	3
	$c = 3.25$,	$\alpha = 0.1968$,
	Accept H_0	
Education:		
Bachelor's Degree*	28	8
Graduate Study	86	21
	$c = 0.112$	$\alpha = 0.7376$
	Accept H_0	
Environmental Training:		
Has Had	70	23
Has Not Had	43	6
	$c = 3.08$,	$\alpha = 0.0793$,
	See discussion	

*includes one respondent with no university education.

Table B.10: Effect of EIA on National Development

1. INPUT DATA:

REGION OR GROUP	NUMBER GIVING EACH RESPONSE HOW WILL EIA AFFECT NATIONAL DEVELOPMENT? ENHANCE	 NO EFFECT/RETARD
DEVELOPING:		
a) Africa and Middle East	30	8
b) Americas	45	6
c) Asia and the Pacific	27	18
d) Europe	1	4
INDUSTRIALIZED:		
e) United States	25	36
f) Canada	11	14
g) Other Industrialized	16	23
h) All Developing	103	36
i) All Industrialized	52	73

2. TEST RESULTS:

COMPARING	TEST STATISTIC	α	DECISION
a, b, c, d, e, f and g	43.05	0.0001	Accept H_1
h and i	28.68	0.0001	Accept H_1
a, b and c	10.72	0.0047	Accept H_1

Table B.10: Continued

CATEGORY	NUMBER GIVING EACH RESPONSE HOW WILL EIA AFFECT NATIONAL DEVELOPMENT?	
	ENHANCE	NO EFFECT/RETARD
Employment:		
Government	45	14
Education	40	15
Other	18	7
	c = 0.26,	α = 0.8797,
	Accept H_0	
Education:		
Bachelor's Degree*	34	3
Graduate Study	69	33
	c = 8.32,	α = 0.0039
	Accept H_1	
Environmental Training:		
Has Had	64	25
Has Not Had	38	11
	c = 0.52,	α = 0.4702,
	Accept H_0	

*includes one respondent with no university education.

among third world respondents, answers were dependent upon level of education.

EIA and Project Planning

Table B.11 summarizes answers pertaining to the effect of EIA on project planning. Responses were found to be dependent upon the level of development of the respondent's country. However, responses from the third world were independent of geographical region, sector of employment and education. The chi-square test based on specialized environmental training again yielded a statistic in a "grey area". H_1 is accepted at the $\alpha = 0.10$ level, but rejected at the $\alpha = 0.05$ level.

The results of these statistical tests are discussed in Chapter VI, under the heading "EIA Cost and National Development".

Importance of Environmental Parameters

In Part 3 of the questionnaire, respondents were asked to rate the importance of changes in each of 18 environmental parameters. The Kruskal-Wallis test was used to determine whether differences were significant or not. The test was

H_0: All populations gave essentially the same rating,

versus

H_1: Some populations gave higher ratings than the rest.

These sets of comparisons were done on each parameter. In the first test, four regions of developing nations and three regions of industrialized nations were compared. The input data was average state responses for the United States, average province responses for Canada, and average country responses for the other industrialized nations

Table B.11: Effect of EIA on Project Planning

1. INPUT DATA:

REGION OR GROUP	NUMBER GIVING EACH RESPONSE HOW WILL EIA AFFECT PROJECT PLANNING? ENHANCE	 NO EFFECT/RETARD
DEVELOPING:		
a) Africa and Middle East	31	8
b) Americas	43	10
c) Asia and the Pacific	35	10
d) Europe	2	4
INDUSTRIALIZED:		
e) United States	44	18
f) Canada	19	8
g) Other Industrialized	24	18
h) All Developing	111	32
i) All Industrialized	87	44

2. TEST RESULTS:

COMPARING	TEST STATISTIC	α	DECISION
a, b, c, d, e, f and g	13.21	0.0399	Accept H_1
h and i	4.29	0.0384	Accept H_1
a, b and c	0.17	0.9192	Accept H_0

Table B.11: Continued

CATEGORY	NUMBER GIVING EACH RESPONSE HOW WILL EIA AFFECT PROJECT PLANNING? ENHANCE	 NO AFFECT/RETARD
Employment:		
Government	48	14
Education	43	13
Other	20	5
	c = 0.11,	α = 0.9487
	Accept H_0	
Education:		
Bachelor's Degree*	31	8
Graduate Study	79	24
	c = 0.13,	α = 0.7226
	Accept H_0	
Environmental Training:		
Has Had	75	16
Has Not Had	34	16
	c = 3.82,	α = 0.0505
	See discussion	

*includes one respondent with no university education.

Table B.12: Importance of Suspended Solids in Streams

1. **INPUT DATA:**

Region or Group	Number Giving Each Score					
	0	1	2	3	4	5
DEVELOPING:						
a) Africa and Middle East	3	1	6	8	6	3
b) Americas	4	1	2	4	7	4
c) Asia and the Pacific	1	1	3	4	4	4
d) Europe	0	1	0	2	0	0
INDUSTRIALIZED:						
e) United States	0	0	1	11	17	9
f) Canada	0	0	0	3	4	0
g) Other Industrialized	0	2	1	9	4	3
h) ALL DEVELOPING	8	4	11	18	17	11
i) ALL INDUSTRIALIZED	0	2	1	9	6	3

2. **TEST RESULTS:**

Comparing	Test Statistic	α	Decision
a, b, c, d, e, f, and g	12.86	0.0454	Accept H_1
h and i	0.71	0.3985	Accept H_0
a, b, c and d	1.69	0.6382	Accept H_0

Table B.13: Importance of Temperature in Streams

1. INPUT DATA:

	Number Giving Each Score					
Region or Group	0	1	2	3	4	5
DEVELOPING:						
a) Africa and Middle East	6	10	9	1	1	0
b) Americas	6	3	7	4	2	0
c) Asia and the Pacific	5	3	5	2	1	1
d) Europe	0	2	1	0	0	0
INDUSTRIALIZED:						
e) United States	0	1	6	13	13	5
f) Canada	0	0	3	1	3	0
g) Other Industrialized	0	3	3	10	2	1
h) ALL DEVELOPING	17	18	22	7	4	1
i) ALL INDUSTRIALIZED	0	3	3	12	2	1

2. TEST RESULTS:

Comparing	Test Statistic	α	Decision
a, b, c, d, e, f, and g	49.75	0.0001	Accept H_1
h and i	15.90	0.0001	Accept H_1
a, b, c and d	1.16	0.7623	Accept H_0

and the third world. The second test compared all responses from developing countries as one group with all responses from industrialized nations as the other. Here, the input data was in the form of average country responses, with the United States and Canada representing one sample point each among the industrialized nations. The final test compared just the four developing regions. Again, the input data took the form of average country responses.

Physical-Chemical Parameters

The first seven parameters listed all came from the physical-chemical environment. The analysis of their importance rating is as follows.

Suspended Solids in Streams: No significant differences were found among the responses from developing countries. In the direct comparison between "all developing" and "all industrialized" countries, differences were again not significant. However, when all of the seven regional/development-level groups are compared, the differences were found to be significant at the $\alpha = 0.05$ level (see Table B.12).

Temperature in Streams: The differences here were significant in terms of development level, but not in terms of geographical region. Responses from the four developing regions were essentially the same. The comparison between "all developing" and "all industrialized" and that between all seven groups both showed significant differences at the $\alpha = 0.0001$ level (see Table B.13).

Sulfur Dioxide in the Atmosphere: The test results were much the same as with "temperature in streams". Responses from the four developing regions showed no significant differences. The other tests showed differences which were significant at the $\alpha = 0.0005$ level (see Table B.14).

Visibility (Presence of Smoke and Smog): Again, the results showed similar responses from the third world but significant differences between developing and industrialized nations. In this case, the differences were significant at the $\alpha = 0.05$ level (see Table B.15).

Changes in Topography of Land: The importance rating of this parameter showed no differences based on geographical region or level of development (see Table B.16).

Dissolved Solids in Ground Water: The responses from the four developing regions were not significantly different. Neither were those from each of the seven groups. However, when "all developing" countries were compared with "all industrialized" ones, the differences were signficant at the $\alpha = 0.05$ level (see Table B.17).

Salinity in Marine and Estuarine Waters: The importance rating of this parameter showed no differences based on geographical region or level of development (see Table B.18).

Biological Parameters

Respondents were asked to rate the importance of five biological parameters. The responses were as follows.

Replacement of Natural Vegetation: As shown in Table B.19, this parameter showed no differences based on either geographical region or level of development.

Table B.14: Importance of Sulfur Dioxide in the Atmosphere

1. INPUT DATA:

Region or Group	Number Giving Each Score 0	1	2	3	4	5
<u>DEVELOPING:</u>						
a) Africa and Middle East	6	2	5	8	2	5
b) Americas	3	3	3	4	6	3
c) Asia and the Pacific	2	3	2	3	4	2
d) Europe	1	0	0	2	0	0
<u>INDUSTRIALIZED:</u>						
e) United States	0	0	0	11	17	10
f) Canada	0	0	0	2	2	3
g) Other Industrialized	0	0	3	2	6	8
h) ALL DEVELOPING	12	8	10	17	12	10
i) ALL INDUSTRIALIZED	0	0	3	2	8	8

2. TEST RESULTS:

Comparing	Test Statistic	α	Decision
a, b, c, d, e, f, and g	26.15	0.0002	Accept H_1
h and i	12.02	0.0005	Accept H_1
a, b, c and d	0.75	0.8613	Accept H_0

Table B.15: Importance of Visibility (presence of smoke and smog)

1. INPUT DATA:

Region or Group	Number Giving Each Score 0	1	2	3	4	5
DEVELOPING:						
a) Africa and Middle East	8	6	5	2	5	2
b) Americas	2	6	6	3	4	2
c) Asia and the Pacific	3	2	4	4	2	2
d) Europe	0	1	0	2	0	0
INDUSTRIALIZED:						
e) United States	0	1	4	14	13	5
f) Canada	0	0	2	2	2	1
g) Other Industrialized	0	3	4	5	5	2
h) ALL DEVELOPING	13	15	15	11	11	6
i) ALL INDUSTRIALIZED	0	3	4	7	5	2

2. TEST RESULTS:

Comparing	Test Statistic	α	Decision
a, b, c, d, e, f, and g	20.80	0.0020	Accept H_1
h and i	4.62	0.0316	Accept H_1
a, b, c and d	1.72	0.6321	Accept H_0

Table B.16: Importance of Changes in Topography of Land

1. INPUT DATA:

	Number Giving Each Score					
Region or Group	0	1	2	3	4	5
DEVELOPING:						
a) Africa and Middle East	1	6	6	7	2	5
b) Americas	1	1	3	10	5	3
c) Asia and the Pacific	1	0	4	8	3	1
d) Europe	0	1	1	0	1	0
INDUSTRIALIZED:						
e) United States	0	7	12	12	3	4
f) Canada	0	1	3	1	2	0
g) Other Industrialized	0	1	2	10	3	3
h) ALL DEVELOPING	3	8	14	25	11	9
i) ALL INDUSTRIALIZED	0	1	2	12	3	3

2. TEST RESULTS:

Comparing	Test Statistic	α	Decision
a, b, c, d, e, f, and g	7.37	0.2880	Accept H_0
h and i	1.30	0.2544	Accept H_0
a, b, c and d	2.45	0.4836	Accept H_0

Table B.17: Importance of Dissolved Solids in Ground Water

1. **INPUT DATA:**

Region or Group	Number Giving Each Score 0	1	2	3	4	5
DEVELOPING:						
a) Africa and Middle East	4	2	5	8	4	5
b) Americas	3	2	4	8	3	2
c) Asia and the Pacific	1	2	4	5	3	2
d) Europe	1	0	0	1	0	1
INDUSTRIALIZED:						
e) United States	0	2	4	10	15	6
f) Canada	0	0	1	2	4	0
g) Other Industrialized	0	0	3	7	5	4
h) ALL DEVELOPING	9	6	13	22	10	10
i) ALL INDUSTRIALIZED	0	0	3	8	6	4

2. **TEST RESULTS:**

Comparing	Test Statistic	α	Decision
a, b, c, d, e, f, and g	10.47	0.1062	Accept H_0
h and i	4.76	0.0292	Accept H_1
a, b, c and d	0.25	0.9684	Accept H_0

Table B.18: Importance of Salinity in Marine and Estuarine Waters

1. INPUT DATA:

	Number Giving Each Score					
Region or Group	0	1	2	3	4	5
DEVELOPING:						
a) Africa and Middle East	5	3	6	7	3	4
b) Americas	5	1	5	8	3	1
c) Asia and the Pacific	1	3	3	6	2	2
d) Europe	0	0	2	1	0	0
INDUSTRIALIZED:						
e) United States	0	4	9	11	11	2
f) Canada	0	0	3	3	1	0
g) Other Industrialized	1	3	8	3	3	0
h) ALL DEVELOPING	11	7	16	22	8	7
i) ALL INDUSTRIALIZED	1	3	8	5	3	0

2. TEST RESULTS:

Comparing	Test Statistic	α	Decision
a, b, c, d, e, f, and g	5.53	0.4773	Accept H_0
h and i	4.76	0.6455	Accept H_0
a, b, c and d	0.54	0.9110	Accept H_0

Table B.19: Importance of Replacement of Natural Vegetation

1. INPUT DATA:

Region or Group	Number Giving Each Score 0	1	2	3	4	5
DEVELOPING:						
a) Africa and Middle East	2	2	3	3	6	12
b) Americas	0	0	3	7	7	5
c) Asia and the Pacific	0	0	1	8	5	3
d) Europe	0	0	1	1	1	0
INDUSTRIALIZED:						
e) United States	1	1	6	12	14	4
f) Canada	0	0	2	4	1	0
g) Other Industrialized	0	0	4	6	7	2
h) ALL DEVELOPING	2	2	8	19	19	20
i) ALL INDUSTRIALIZED	0	0	4	8	7	2

2. TEST RESULTS:

Comparing	Test Statistic	α	Decision
a, b, c, d, e, f, and g	6.50	0.3694	Accept H_0
h and i	1.44	0.2297	Accept H_0
a, b, c and d	1.70	0.6377	Accept H_0

Obstruction of Animal Migration Routes: When all seven regional/development-level groups were compared, the differences were found to be significant at the $\alpha = 0.05$ level (see Table B.20). However, the comparison between "all developing" and "all industrialized" countries showed no significant differences. Differences among the developing nations were also not significant.

Reduction in Species Diversity: When all seven regional/development-level groups were compared, the result was in a "grey area" (see Table B.21). The differences are significant at the $\alpha = 0.10$ level, but not significant at the $\alpha = 0.05$ level. Differences among developing countries were significant at the latter level. However, differences between the "all developing" and "all industrialized" groups were not significant.

Reduction in Numbers of a Given Species: As shown in Table B.22, there were no differences in the rating of this parameter based on geographical region or level of development.

Rare or Endangered Species: Responses to this question are summarized in Table B.23. When all seven regional/development-level groups were compared, the differences were found to be significant at the $\alpha = 0.05$ level. However, there were no significant differences between the "all developing" and "all industrialized" groups. Neither were there significant differences among the developing countries.

Socio-Economic Parameters

The ratings of the socio-economic parameters and the test results are summarized in Tables B.24 to B.26.

Table B.20: Importance of Obstruction of Animal Migration Routes

1. INPUT DATA:

Region or Group	Number Giving Each Score 0	1	2	3	4	5
DEVELOPING:						
a) Africa and Middle East	6	4	7	4	5	2
b) Americas	2	4	8	5	2	0
c) Asia and the Pacific	3	5	4	3	2	0
d) Europe	0	2	0	0	1	0
INDUSTRIALIZED:						
e) United States	0	5	8	12	8	5
f) Canada	0	0	1	2	3	1
g) Other Industrialized	1	5	6	7	0	0
h) ALL DEVELOPING	11	15	19	12	10	2
i) ALL INDUSTRIALIZED	1	5	6	8	1	0

2. TEST RESULTS:

Comparing	Test Statistic	α	Decision
a, b, c, d, e, f, and g	19.25	0.0038	Accept H_1
h and i	0.29	0.5899	Accept H_0
a, b, c and d	0.72	0.8683	Accept H_0

Table B.21: Importance of Reduction in Species Diversity

1. INPUT DATA:

Region or Group	Number Giving Each Score 0	1	2	3	4	5
DEVELOPING:						
a) Africa and Middle East	3	7	3	4	7	4
b) Americas	0	0	2	5	8	8
c) Asia and the Pacific	1	0	4	6	3	3
d) Europe	0	1	0	1	1	0
INDUSTRIALIZED:						
e) United States	0	3	2	11	15	6
f) Canada	0	1	0	4	1	1
g) Other Industrialized	0	0	4	7	6	2
h) ALL DEVELOPING	4	8	9	16	19	15
i) ALL INDUSTRIALIZED	0	0	4	9	6	2

2. TEST RESULTS:

Comparing	Test Statistic	α	Decision
a, b, c, d, e, f, and g	12.10	0.0599	See discussion
h and i	0.01	0.9074	Accept H_0
a, b, c and d	9.44	0.0240	Accept H_1

Table B.22: Importance of Reduction in Numbers of a Given Species

1. INPUT DATA:

Region or Group	Number Giving Each Score 0	1	2	3	4	5
DEVELOPING:						
a) Africa and Middle East	1	7	5	2	8	8
b) Americas	0	0	3	8	4	7
c) Asia and the Pacific	0	0	3	7	5	2
d) Europe	0	0	1	1	1	0
INDUSTRIALIZED:						
e) United States	0	5	3	12	14	4
f) Canada	0	1	0	3	3	0
g) Other Industrialized	0	0	8	3	7	1
h) ALL DEVELOPING	1	7	12	18	18	13
i) ALL INDUSTRIALIZED	0	0	8	5	7	1

2. TEST RESULTS:

Comparing	Test Statistic	α	Decision
a, b, c, d, e, f, and g	5.11	0.5294	Accept H_0
h and i	0.53	0.4684	Accept H_0
a, b, c and d	4.38	0.2234	Accept H_0

Table B.23: Importance of Rare or Endangered Species

1. INPUT DATA:

	Number Giving Each Score					
Region or Group	0	1	2	3	4	5
DEVELOPING:						
a) Africa and Middle East	3	1	5	5	7	6
b) Americas	0	0	2	6	4	10
c) Asia and the Pacific	0	0	2	5	7	3
d) Europe	0	0	1	1	0	1
INDUSTRIALIZED:						
e) United States	0	1	3	3	10	22
f) Canada	0	1	0	0	2	4
g) Other Industrialized	0	1	1	4	6	7
h) ALL DEVELOPING	3	1	10	17	18	20
i) ALL INDUSTRIALIZED	0	1	1	4	8	7

2. TEST RESULTS:

Comparing	Test Statistic	α	Decision
a, b, c, d, e, f, and g	13.14	0.0409	Accept H_1
h and i	1.12	0.2896	Accept H_0
a, b, c and d	4.09	0.2524	Accept H_0

Table B.24: Importance of Employment

1. INPUT DATA:

	Number Giving Each Score					
Region or Group	0	1	2	3	4	5
DEVELOPING:						
a) Africa and Middle East	3	1	2	1	10	10
b) Americas	1	1	1	5	8	6
c) Asia and the Pacific	0	1	1	7	4	4
d) Europe	0	1	0	1	1	0
INDUSTRIALIZED:						
e) United States	0	2	5	14	10	9
f) Canada	0	0	0	1	5	1
g) Other Industrialized	3	1	2	4	4	5
h) ALL DEVELOPING	4	4	4	14	23	20
i) ALL INDUSTRIALIZED	3	1	2	5	5	5

2. TEST RESULTS:

Comparing	Test Statistic		Decision
a, b, c, d, e, f, and g	4.68	0.5849	Accept H_0
h and i	1.20	0.2726	Accept H_0
a, b, c and d	2.44	0.4855	Accept H_0

Table B.25: Importance of Reduced Food Imports

1. INPUT DATA:

Region or Group	Number Giving Each Score 0	1	2	3	4	5
DEVELOPING:						
a) Africa and Middle East	3	1	4	5	5	10
b) Americas	3	2	4	5	5	3
c) Asia and the Pacific	0	2	4	2	6	3
d) Europe	1	0	0	1	1	0
INDUSTRIALIZED:						
e) United States	4	13	10	5	1	3
f) Canada	1	4	2	0	0	0
g) Other Industrialized	5	5	5	1	1	2
h) ALL DEVELOPING	7	5	12	13	17	16
i) ALL INDUSTRIALIZED	5	6	6	1	1	2

2. TEST RESULTS:

Comparing	Test Statistic	α	Decision
a, b, c, d, e, f, and g	25.81	0.0002	Accept H_1
h and i	11.03	0.0009	Accept H_1
a, b, c and d	2.79	0.4244	Accept H_0

Table B.26: Importance of Health Effects

1. INPUT DATA:

	Number Giving Each Score					
Region or Group	0	1	2	3	4	5
DEVELOPING:						
a) Africa and Middle East	1	1	0	4	6	16
b) Americas	0	0	2	3	8	9
c) Asia and the Pacific	0	0	0	4	6	7
d) Europe	0	0	0	1	1	1
INDUSTRIALIZED:						
e) United States	0	1	1	4	9	23
f) Canada	0	0	0	1	2	4
g) Other Industrialized	0	0	0	1	9	9
h) ALL DEVELOPING	1	1	2	12	21	33
i) ALL INDUSTRIALIZED	0	0	0	1	11	9

2. TEST RESULTS:

Comparing	Test Statistic	α	Decision
a, b, c, d, e, f, and g	2.74	0.8412	Accept H_0
h and i	0.20	0.6512	Accept H_0
a, b, c and d	0.94	0.8162	Accept H_0

Employment: Responses to this question showed no significant differences based on geographical region or level of development.

Reduced Food Imports: Responses from developing countries were not significantly different from each other. However, those from the third world differed significantly from those from industrialized nations at the $\alpha = 0.001$ level.

Health Effects: Again, no significant differences based on geographical region or level of development were noted.

Cultural Parameters

The ratings of the three cultural parameters and the test results are summarized in Tables B.27 to B.29.

Archaeological Sites: When all seven regions were compared, and when "all developing" were compared with "all industrialized" nations, no significant differences were noted. The comparison among the four developing regions yielded results in the "grey area". Differences were found to be significant at the $\alpha = 0.10$ level, but not at the $\alpha = 0.05$ level.

Scenic Areas: There were no significant differences of response based on level of development or geographical region.

Religious Practices: Each of the three tests performed showed differences which were significant at the $\alpha = 0.002$ level.

Environmental Priorities

A series of Kruskal-Wallis tests was done to determine if, for a particular developing region, greater importance was placed on one group of parameters than others. The Kruskal-Wallis test is a test of

Table B.27: Importance of Archeological Sites

1. **INPUT DATA:**

	Number Giving Each Score					
Region or Group	0	1	2	3	4	5
DEVELOPING:						
a) Africa and Middle East	2	5	10	4	3	4
b) Americas	2	0	4	7	6	3
c) Asia and the Pacific	0	1	5	3	6	2
d) Europe	0	0	0	1	0	2
INDUSTRIALIZED:						
e) United States	0	3	6	11	12	8
f) Canada	0	1	0	3	3	0
g) Other Industrialized	0	1	4	6	5	3
h) ALL DEVELOPING	4	6	19	15	15	11
i) ALL INDUSTRIALIZED	0	1	4	8	5	3

2. **TEST RESULTS:**

Comparing	Test Statistic	α	Decision
a, b, c, d, e, f, and g	10.54	0.1035	Accept H_0
h and i	0.77	0.3810	Accept H_0
a, b, c and d	6.98	0.0726	See Discussion

Table B.28: Importance of Scenic Areas

1. INPUT DATA:

	Number Giving Each Score					
Region or Group	0	1	2	3	4	5
DEVELOPING:						
a) Africa and Middle East	1	2	8	7	4	5
b) Americas	0	1	1	8	8	5
c) Asia and the Pacific	0	1	3	6	4	3
d) Europe	0	1	1	0	1	0
INDUSTRIALIZED:						
e) United States	0	2	5	16	13	3
f) Canada	0	0	1	3	3	0
g) Other Industrialized	1	2	2	4	7	3
h) ALL DEVELOPING	1	5	13	21	17	13
i) ALL INDUSTRIALIZED	1	2	2	6	7	3

2. TEST RESULTS:

Comparing	Test Statistic	α	Decision
a, b, c, d, e, f, and g	5.49	0.4824	Accept H_0
h and i	0.00	0.9662	Accept H_0
a, b, c and d	5.05	0.1684	Accept H_0

Table B.29: Importance of Effects on Religious Practices

1. INPUT DATA:

	Number Giving Each Score					
Region or Group	0	1	2	3	4	5
DEVELOPING:						
a) Africa and Middle East	9	4	5	4	2	4
b) Americas	4	6	9	1	1	1
c) Asia and the Pacific	1	0	5	2	5	4
d) Europe	1	0	0	2	0	0
INDUSTRIALIZED:						
e) United States	5	14	9	5	2	2
f) Canada	1	3	2	0	1	0
g) Other Industrialized	8	6	4	0	1	0
h) ALL DEVELOPING	15	10	19	9	8	9
i) ALL INDUSTRIALIZED	8	7	5	0	1	0

2. TEST RESULTS:

Comparing	Test Statistic	α	Decision
a, b, c, d, e, f, and g	20.49	0.0023	Accept H_1
h and i	8.28	0.0040	Accept H_1
a, b, c and d	10.25	0.0165	Accept H_1

several independent samples. There is a school of thought that parameter ratings from a particular region may not be independent samples. The argument is that if a region suffers from acute unfulfilled basic needs, all socio-economic parameters would tend to be highly rated. Similarly, if a region contains a predominance of fragile ecosystems, biological parameters will generally be considered very important. Thus, knowing the rating of one parameter would indicate something about other ratings in the same environmental group.

In recognition of the arguments just presented, a test for independence was run on part of the data before the Kruskal-Wallis tests were performed. The procedure involved a series of pairwise comparisons between various parameter ratings. The responses from Africa and the Middle East were used for this test, since this region contained the largest number of data points. The responses were compared in the form of 28 average country responses for each parameter rated. The test procedure was a chi-square test for independence.

In order to satisfy the rule-of-thumb that each cell in the contingency table should have an expected value of 5 or more, the responses to each question were partitioned into 2 classes. Each pair of classes was chosen to given as close as possible to a half-and-half split. In most cases the classes were "less than average importance (0, 1 or 2)" and "average or greater importance (3, 4 or 5)". In other cases, a different division was indicated by the data. For example, the ratings for employment were all very high. So the two classes used were "extremely important (5)" and "less than extremely important (0 to 4)".

All possible pairs of parameters in each group were tested for independence. The results of each pair formed a 2 x 2 contingency table. The test on each pair was

H_0: The rating of parameter "A" is independent of the rating of parameter "B",

versus

H_1: The rating of parameter "A" is dependent upon the rating of parameter "B".

The results of the 37 tests are listed in Table B.30. No dependence was noted among the socio-economic or cultural parameters. Dependence was noted in only 5 of the 21 pairs of physical-chemical parameters. Only among the biological parameters was there dependence in the majority (7 out of 10) of pairs. It was therefore concluded that, in general, the parameter ratings are independent observations. This test was not repeated for other regions, because the small number of countries represented there made it impossible to consistently achieve the desired minimum of 5 observations in each cell of a 2 x 2 contingency table.

The Kruskal-Wallis tests on responses from each of the seven geographical/development level regions are summarized in Tables B.31 to B.37. The tests were

H_0: All groups of parameters received essentially the same importance ratings,

versus

H_1: Some groups of parameters tended to receive higher importance ratings than the rest.

The results of tests on ratings from the developing Americas and developing Europe showed no greater importance being given to any of

Table B.30: Pairwise Comparison of Parameter Ratings from Africa and the Middle East

COMPARE	α	ACCEPT
Physical-Chemical Parameters		
Q13 & Q14	>>.25	H_0
Q13 & Q15	>.25	H_0
Q13 & Q16	>.25	H_0
Q13 & Q17	>>.25	H_0
Q13 & Q18	>>.25	H_0
Q13 & Q19	>.25	H_0
Q14 & Q15	<.01	H_1
Q14 & Q16	<.005	H_1
Q14 & Q17	>.05	H_0
Q14 & Q18	<.05	H_1
Q14 & Q19	>.25	H_0
Q15 & Q16	<.005	H_1
Q15 & Q17	>>.25	H_0
Q15 & Q18	<<.001	H_1
Q15 & Q19	>.05	H_0
Q16 & Q17	>.10	H_0
Q16 & Q18	>.25	H_0
Q16 & Q19	>.10	H_0
Q17 & Q18	>.25	H_0
Q17 & Q19	>.10	H_0
Q18 & Q19	>.05	H_0

COMPARE	α	ACCEPT
Biological Parameters		
Q20 & Q21	>.05	H_0
Q20 & Q22	>.10	H_0
Q20 & Q23	<.05	H_1
Q20 & Q24	>.05	H_0
Q21 & Q22	<<.001	H_1
Q21 & Q23	<.01	H_1
Q21 & Q24	<.05	H_1
Q22 & Q23	<.025	H_1
Q22 & Q24	<.05	H_1
Q23 & Q24	<.025	H_1
Socio-Economic Parameters		
Q25 & Q26	>.05	H_0
Q25 & Q27	>.05	H_0
Q26 & Q27	>.10	H_0
Cultural Parameters		
Q28 & Q29	<.05	H_0
Q28 & Q30	>.05	H_0
Q29 & Q30	> .10	H_0

Table B.31: Kruskal-Wallis Test on Parameter Importance Ratings from Africa and the Middle East

	Phys-Chem.		Biological		Socio-Econ.		Cultural	
	Rating	Rank	Rating	Rank	Rating	Rank	Rating	Rank
	2.86	12	3.61	16	3.63	17	2.46	6.5
	1.30	1	2.14	4	3.36	15	2.96	13
	2.46	6.5	2.61	8	4.18	18	1.93	3
	1.86	2	2.78	11				
	2.67	9	3.11	14				
	2.75	10						
	2.43	5						
R_i:		45.5		53		50		22.5
n_i:		7		5		3		3

N = 18

$S^2 = 28.47$

$T = 8.26$

$0.05 < \alpha < 0.10$

See discussion

Table B.32: Kruskal-Wallis Test on Parameter Importance Ratings from the Developing Americas

	Phys-Chem.		Biological		Socio-Econ.		Cultural	
	Rating	Rank	Rating	Rank	Rating	Rank	Rating	Rank
	2.95	9	3.64	12.5	3.64	12.5	3.09	10
	1.68	2	2.05	3	2.73	7.5	3.65	14
	2.73	7.5	3.96	16	4.09	18	1.64	1
	2.30	5	3.68	15				
	3.13	11	4.00	17				
	2.55	6						
	2.26	4						
R_i:		44.5		63.5		38		25
n_i:		7		5		3		3

N = 18

$S^2 = 28.03$

$T = 5.51$

$0.1 < \alpha < 0.25$

Accept H_0

Table B.33: Kruskal-Wallis Test on Parameter Importance Ratings from Asia and the Pacific

	Phys-Chem.		Biological		Socio-Econ.		Cultural	
	Rating	Rank	Rating	Rank	Rating	Rank	Rating	Rank
	3.24	10.5	3.59	16	3.53	15	3.18	9
	1.65	1	1.76	2	3.24	10.5	3.29	12.5
	2.63	4	3.12	8	4.18	18	3.29	12.5
	2.35	3	3.35	14				
	2.88	7	3.65	17				
	2.76	6						
	2.65	5						
R_i:		36.5		57		43.5		34
n_i:		7		5		3		3

N = 18

$S^2 = 28.03$

$T = 8.66$

$0.05 < \alpha < 0.10$

See discussion.

Table B.34: Kruskal-Wallis Test on Parameter Importance Ratings from Developing Europe

	Phys-Chem.		Biological		Socio-Econ.		Cultural	
	Rating	Rank	Rating	Rank	Rating	Rank	Rating	Rank
	2.33	7.5	3.00	14.5	2.67	12	4.33	18
	1.33	1	2.00	3	2.33	7.5	2.33	7.5
	2.00	3	2.67	12	4.00	17	2.00	3
	2.33	7.5	3.00	14.5				
	2.33	7.5	3.33	16				
	2.67	12						
	2.33	7.5						
R_i:		46		60		36.5		28.5
n_i:		7		5		3		3

N = 18

$S^2 = 27.21$

$T = 4.14$

$0.10 < \alpha < 0.25$

Accept H_0

Table B.35: Kruskal-Wallis Test on Parameter Importance Ratings from the United States

	Phys-Chem.		Biological		Socio-Econ.		Cultural	
	Rating	Rank	Rating	Rank	Rating	Rank	Rating	Rank
	3.89	16	3.29	8	3.47	12	3.40	10
	3.39	9	3.00	5	1.86	2	3.26	7
	3.79	15	3.51	13.5	4.37	18	1.76	1
	3.46	11	3.24	6				
	2.61	3	4.26	17				
	3.51	13.5						
	2.95	4						
R_i:		71.5		49.5		32		18
n_i:		7		5		3		3

N = 18

$S^2 = 28.47$

$T = 1.59$

$\alpha > 0.25$

Accept H_0

Table B.36: Kruskal-Wallis Test on Parameter Importance Ratings from Canada

	Phys-Chem.		Biological		Socio-Econ.		Cultural	
	Rating	Rank	Rating	Rank	Rating	Rank	Rating	Rank
	3.57	13.5	2.86	5	4.00	15	3.14	8
	3.00	6	3.57	13.5	1.14	1	3.29	10.5
	4.14	16.5	3.14	8	4.43	18	1.57	2
	3.29	10.5	3.14	8				
	2.57	3	4.14	16.5				
	3.43	12						
	2.71	4						
R_i:		65.5		51		34		20.5
n_i:		7		5		3		3

N = 18

$S^2 = 28.29$

T = 1.20

$\alpha > 0.25$

Accept H_0

Table B.37: Kruskal-Wallis Test on Parameter Importance Ratings from Other Industrialized Nations

	Phys-Chem.		Biological		Socio-Econ.		Cultural	
	Rating	Rank	Rating	Rank	Rating	Rank	Rating	Rank
	3.26	11	3.37	14	3.05	7.5	3.26	11
	2.74	5	2.00	3	1.68	2	3.21	9
	4.00	17	3.32	13	4.42	18	0.95	1
	2.95	6	3.05	7.5				
	3.26	11	3.89	16				
	3.53	15						
	2.22	4						
R_i:		69		53.5		27.5		21
n_i:		7		5		3		3

N = 18

$S^2 = 28.35$

$T = 0.96$

$\alpha >> 0.25$

Accept H_0

the environmental groups. The same held for the ratings from the United States, Canada and the other industrialized countries. Those from Africa and the Middle East showed a tendency to rate socio-economic parameters higher than others. This was significant at the $\alpha = 0.10$ level, but not at the $\alpha = 0.05$ level, in both cases. These results and all others related to parameter importance ratings are discussed in Chapter VI, under the heading "Importance of Environmental Parameters".

Criteria Importance

In Part 4 of the questionnaire, respondents were asked to rate the importance of nine criteria for evaluating EIA methodologies. Three of these were relevant to the impact identification exercise, one to the baseline study, two to impact evaluation and five to comparing alternatives. A series of three Kruskal-Wallis tests was conducted on the rating of each criterion. The data was analyzed in the form of average country, state or province ratings. In the first test, the seven developing and industrialized regions were all compared. In the second test, all developing countries as a group were compared with all industrialized countries as a second group. In the latter group, the United States and Canada each counted as one country (instead of several states or provinces). The final test compared the four developing regions. The tests were

H_0: all regions/levels of development gave the same rating,

versus

H_1: some regions/levels of development gave higher ratings.

The input data and test results for each of the nine criteria are shown in Tables B.38 to B.46. In eight of the nine cases, there were no significant differences based on either geographical region or level of development. In the case of the data criterion, the ratings from the United States and Canada were significantly lower at the α = 0.05 level.

Because there were no significant differences in rating among the developing countries, these responses were pooled and tested for differences based on respondent's sector of employment, level of educational attainment and specialized environmental training. In order to do this, it was necessary to analyze the data in the form of individual responses. This differs from the previous set of tests, which were based on average country responses. Again, the Kruskal-Wallis test was used. The test was

> H_0: all employment sectors (or educational levels, or specialized training groups) gave the same rating,

versus

> H_1: some employment sectors (or educational levels, or specialized training groups) gave higher ratings.

The input data and test results for each of the nine criteria are shown in Tables B.47 to B.55. Again, the general result was that there were no significant differences based on employment, education or specialized environmental training. In the case of the objectivity criterion, there was some indication that persons with a bachelor's degree tended to assign a lower rating than those who had done graduate studies. However, this tendency was not strong, H_1 being accepted at the $\alpha = 0.10$ level, but rejected at the $\alpha = 0.05$ level.

Table B.38: Criteria Importance: Comprehensiveness

1. INPUT DATA:

Region or Group	Number Giving Each Score					
	0	1	2	3	4	5
DEVELOPING:						
a) Africa and Middle East	1	1	0	4	12	9
b) Americas	0	0	1	5	8	8
c) Asia and the Pacific	0	0	1	3	5	8
d) Europe	0	0	0	1	1	1
INDUSTRIALIZED:						
e) United States	0	0	1	4	12	23
f) Canada	0	0	0	0	5	2
g) Other Industrialized	0	0	0	3	9	7
h) ALL DEVELOPING	1	1	2	13	26	26
i) ALL INDUSTRIALIZED	0	0	0	3	11	7

2. TEST RESULTS:

Comparing	Test Statistic	α	Decision
a, b, c, d, e, f, and g	4.63	0.5915	Accept H_0
h and i	0.08	0.7820	Accept H_0
a, b, c and d	0.43	0.9344	Accept H_0

Table B.39: Criteria Importance: Objectivity

1. INPUT DATA:

	Number Giving Each Score					
Region or Group	0	1	2	3	4	5
<u>DEVELOPING</u>:						
a) Africa and Middle East	1	1	2	6	1	16
b) Americas	0	0	0	3	8	12
c) Asia and the Pacific	0	0	2	2	6	7
d) Europe	0	0	0	0	0	3
<u>INDUSTRIALIZED</u>:						
e) United States	0	2	1	12	6	19
f) Canada	0	0	0	2	4	1
g) Other Industrialized	0	0	2	2	7	8
h) ALL DEVELOPING	1	1	4	11	15	38
i) ALL INDUSTRIALIZED	0	0	2	2	9	8

2. TEST RESULTS:

Comparing	Test Statistic	α	Decision
a, b, c, d, e, f, and g	4.73	0.5783	Accept H_0
h and i	0.51	0.4770	Accept H_0
a, b, c and d	2.57	0.4625	Accept H_0

Table B.40: Criteria Importance: Flexibility

1. INPUT DATA:

	Number Giving Each Score					
Region or Group	0	1	2	3	4	5
DEVELOPING:						
a) Africa and Middle East	1	1	0	5	10	10
b) Americas	0	0	0	3	9	11
c) Asia and the Pacific	0	0	2	3	7	5
d) Europe	0	0	0	1	1	1
INDUSTRIALIZED:						
e) United States	0	1	2	7	20	10
f) Canada	0	0	1	1	5	0
g) Other Industrialized	0	0	1	5	8	5
h) ALL DEVELOPING	1	1	2	12	27	27
i) ALL INDUSTRIALIZED	0	0	1	5	10	5

2. TEST RESULTS:

Comparing	Test Statistic	α	Decision
a, b, c, d, e, f, and g	5.54	0.4762	Accept H_0
h and i	0.97	0.3249	Accept H_0
a, b, c and d	2.18	0.5368	Accept H_0

Table B.41: Criteria Importance: Implementation

1. INPUT DATA:

	Number Giving Each Score					
Region or Group	0	1	2	3	4	5
DEVELOPING:						
a) Africa and Middle East	1	1	1	2	6	16
b) Americas	0	0	0	3	8	12
c) Asia and the Pacific	1	0	2	2	3	9
d) Europe	0	0	1	0	1	1
INDUSTRIALIZED:						
e) United States	0	0	3	10	15	12
f) Canada	0	0	0	3	4	0
g) Other Industrialized	0	1	1	1	11	5
h) ALL DEVELOPING	2	1	4	7	18	38
i) ALL INDUSTRIALIZED	0	1	1	1	13	15

2. TEST RESULTS:

Comparing	Test Statistic	α	Decision
a, b, c, d, e, f, and g	9.21	0.1621	Accept H_0
h and i	2.36	0.1247	Accept H_0
a, b, c and d	0.90	0.8245	Accept H_0

Table B.42: Criteria Importance: Data

1. INPUT DATA:

	Number Giving Each Score					
Region or Group	0	1	2	3	4	5
DEVELOPING:						
a) Africa and Middle East	0	3	1	3	8	12
b) Americas	0	0	2	2	11	8
c) Asia and the Pacific	0	1	0	3	4	9
d) Europe	0	1	0	0	2	0
INDUSTRIALIZED:						
e) United States	1	2	4	14	15	4
f) Canada	0	0	1	3	3	0
g) Other Industrialized	0	2	1	3	8	5
h) ALL DEVELOPING	0	5	3	8	25	29
i) ALL INDUSTRIALIZED	0	2	1	5	8	5

2. TEST RESULTS:

Comparing	Test Statistic	α	Decision
a, b, c, d, e, f, and g	16.02	0.0136	Accept H_1
h and i	2.22	0.1367	Accept H_0
a, b, c and d	2.14	0.5440	Accept H_0

Table B.43: Criteria Importance: Comparisons

1. INPUT DATA:

	Number Giving Each Score					
Region or Group	0	1	2	3	4	5
DEVELOPING:						
a) Africa and Middle East	0	3	4	5	8	7
b) Americas	0	0	1	6	9	5
c) Asia and the Pacific	0	0	3	7	5	2
d) Europe	0	0	0	0	2	1
INDUSTRIALIZED:						
e) United States	0	1	2	11	16	10
f) Canada	0	0	0	3	4	0
g) Other Industrialized	0	0	2	7	6	4
h) ALL DEVELOPING	0	3	8	18	24	15
i) ALL INDUSTRIALIZED	0	0	2	7	8	4

2. TEST RESULTS:

Comparing	Test Statistic	α	Decision
a, b, c, d, e, f, and g	5.09	0.5320	Accept H_0
h and i	0.01	0.9230	Accept H_0
a, b, c and d	3.62	0.3050	Accept H_0

Table B.44: Criteria Importance: Public Involvement

1. INPUT DATA:

Region or Group	Number Giving Each Score 0	1	2	3	4	5
DEVELOPING:						
a) Africa and Middle East	2	2	3	6	9	5
b) Americas	0	0	2	6	5	10
c) Asia and the Pacific	0	0	2	5	4	6
d) Europe	0	0	0	1	2	0
INDUSTRIALIZED:						
e) United States	0	2	1	5	15	17
f) Canada	0	0	1	0	4	2
g) Other Industrialized	0	0	2	5	10	2
h) ALL DEVELOPING	2	2	7	18	20	21
i) ALL INDUSTRIALIZED	0	0	2	5	12	2

2. TEST RESULTS:

Comparing	Test Statistic	α	Decision
a, b, c, d, e, f, and g	9.41	0.1519	Accept H_0
h and i	0.10	0.7559	Accept H_0
a, b, c and d	3.61	0.3065	Accept H_0

Table B.45: Criteria Importance: Impact Prediction

1. INPUT DATA:

	Number Giving Each Score					
Region or Group	0	1	2	3	4	5
DEVELOPING:						
a) Africa and Middle East	1	0	1	3	8	14
b) Americas	0	0	0	2	8	13
c) Asia and the Pacific	0	0	3	0	6	8
d) Europe	0	0	0	1	0	2
INDUSTRIALIZED:						
e) United States	0	0	1	3	9	27
f) Canada	0	0	0	0	3	4
g) Other Industrialized	0	0	0	0	8	11
h) ALL DEVELOPING	1	0	4	6	22	37
i) ALL INDUSTRIALIZED	0	0	0	0	9	12

2. TEST RESULTS:

Comparing	Test Statistic	α	Decision
a, b, c, d, e, f, and g	2.67	0.8494	Accept H_0
h and i	0.58	0.4455	Accept H_0
a, b, c and d	0.65	0.8844	Accept H_0

Table B.46: Criteria Importance: Expertise

1. INPUT DATA:

Region or Group	Number Giving Each Score 0	1	2	3	4	5
DEVELOPING:						
a) Africa and Middle East	1	0	2	10	6	8
b) Americas	0	1	2	6	9	5
c) Asia and the Pacific	1	1	2	3	5	5
d) Europe	0	1	0	1	0	1
INDUSTRIALIZED:						
e) United States	1	4	5	11	14	4
f) Canada	0	0	3	2	2	0
g) Other Industrialized	1	2	2	6	5	3
h) ALL DEVELOPING	2	3	6	20	20	19
i) ALL INDUSTRIALIZED	1	2	2	8	5	3

2. TEST RESULTS:

Comparing	Test Statistic	α	Decision
a, b, c, d, e, f, and g	5.84	0.4415	Accept H_0
h and i	2 17	0.1404	Accept H_0
a, b, c and d	0.35	0.9499	Accept H_0

Table B.47: Third World Criteria Importance Rating: Comprehensiveness

Category	Number Giving Each Score					
	0	1	2	3	4	5
EDUCATION						
Bachelor's*	1	1	4	10	8	21
Graduate	1	4	5	26	24	50
	c = 0.03		α = 0.8669		accept	H_0
EMPLOYMENT						
Government	0	1	4	17	11	34
Education	1	4	3	12	19	21
Other	1	0	2	7	2	17
	c = 2.26		α = 0.3228		accept	H_0
ENVIRONMENTAL TRAINING?						
Yes	1	5	3	26	18	42
No	1	0	6	10	14	28
	c = 0.31		α = 0.5747		accept	H_0

* includes one respondent with no university education

Table B.48: Third World Criteria Importance Rating: Objectivity

Category	Number Giving Each Score					
	0	1	2	3	4	5
<u>EDUCATION</u>						
Bachelor's*	1	2	8	6	10	18
Graduate	0	5	1	22	25	59
	c = 3.4		$\alpha = 0.0630$		see discussion	
<u>EMPLOYMENT</u>						
Government	0	2	6	14	18	28
Education	1	2	3	13	10	31
Other	0	3	0	2	7	18
	c = 2.38		$\alpha = 0.3046$		accept	H_0
<u>ENVIRONMENTAL TRAINING?</u>						
Yes	1	4	4	20	19	48
No	0	3	5	8	15	29
	c = 0.00		$\alpha = 0.9463$		accept	H_0

* includes one respondent with no university education

Table B.49: Third World Criteria Importance Rating: Flexibility

Category	Number Giving Each Score					
	0	1	2	3	4	5
EDUCATION						
Bachelor's*	1	2	3	9	15	14
Graduate	0	2	8	22	29	51
	$c = 1.86$		$\alpha = 0.1724$		accept	H_0
EMPLOYMENT						
Government	0	2	4	15	18	28
Education	1	1	5	11	21	21
Other	0	1	2	6	5	16
	$c = 1.05$		$\alpha = 0.5923$		accept	H_0
ENVIRONMENTAL TRAINING?						
Yes	1	2	6	20	24	42
No	0	2	5	11	19	23
	$c = 0.21$		$\alpha = 0.6435$		accept	H_0

* includes one respondent with no university education

Table B.50: Third World Criteria Importance Rating: Implementation

Category	Number Giving Each Score					
	0	1	2	3	4	5
EDUCATION						
Bachelor's*	1	1	0	7	14	22
Graduate	1	2	9	15	20	65
	c = 0.20		α =0.6581		accept	H_0
EMPLOYMENT						
Government	1	1	4	11	16	35
Education	1	1	3	10	9	36
Other	0	1	2	1	9	17
	c = 0.59		α =0.7453		accept	H_0
ENVIRONMENTAL TRAINING?						
Yes	1	2	5	14	21	53
No	1	1	4	8	13	33
	c = 0.01		α =0.9434		accept	H_0

* includes one respondent with no university education

Table B.51: Third World Criteria Importance Rating: Data

Category	Number Giving Each Score					
	0	1	2	3	4	5
EDUCATION						
Bachelor's*	0	2	3	6	14	20
Graduate	0	5	8	17	28	54
	c = 0.03		α = 0.8674		accept	H_0
EMPLOYMENT						
Government	0	5	3	10	16	34
Education	0	2	6	8	17	27
Other	0	0	2	5	9	14
	c = 0.17		α = 0.9177		accept	H_0
ENVIRONMENTAL TRAINING?						
Yes	0	5	8	14	24	45
No	0	2	3	9	18	28
	c = 0.11		α = 0.7375		accept	H_0

* includes one respondent with no university education

Table B.52: Third World Criteria Importance Rating: Comparisons

Category	Number Giving Each Score					
	0	1	2	3	4	5
<u>EDUCATION</u>						
Bachelor's*	1	2	6	11	12	12
Graduate	0	5	11	30	35	29
	$c = 0.17$		$\alpha = 0.6804$		accept	H_0
<u>EMPLOYMENT</u>						
Government	1	3	9	17	18	20
Education	0	3	8	14	22	13
Other	0	1	0	11	7	8
	$c = 0.42$		$\alpha = 0.8105$		accept	H_0
<u>ENVIRONMENTAL TRAINING?</u>						
Yes	1	5	11	23	27	29
No	0	2	6	18	20	11
	$c = 0.46$		$\alpha = 0.4958$		accept	H_0

* includes one respondent with no university education

Table B.53: Third World Criteria Importance Rating: Public Involvement

Category	Number Giving Each Score					
	0	1	2	3	4	5
<u>EDUCATION</u>						
Bachelor's*	3	2	3	6	13	17
Graduate	2	9	19	27	20	35
	$c = 1.92$		$\alpha = 0.1657$		accept	H_0
<u>EMPLOYMENT</u>						
Government	1	6	5	15	15	26
Education	3	3	11	14	12	17
Other	1	2	6	4	7	9
	$c = 2.14$		$\alpha = 0.3427$		accept	H_0
<u>ENVIRONMENTAL TRAINING?</u>						
Yes	2	8	13	26	16	31
No	3	3	9	7	17	20
	$c = 0.39$		$\alpha = 0.5346$		accept	H_0

* includes one respondent with no university education

Table B.54: Third World Criteria Importance Rating: Impact Prediction

Category	Number Giving Each Score					
	0	1	2	3	4	5
EDUCATION						
Bachelor's*	1	0	2	5	13	23
Graduate	1	3	5	12	26	65
	c = 0.17		α =0.6792		accept	H_0
EMPLOYMENT						
Government	0	1	3	5	18	41
Education	2	1	3	9	15	30
Other	0	1	1	3	7	17
	c = 1.84		α =0.3985		accept	H_0
ENVIRONMENTAL TRAINING?						
Yes	2	2	1	9	24	58
No	0	1	6	8	15	29
	c = 2.10		α =0.1475		accept	H_0

* includes one respondent with no university education

Table B.55: Third World Criteria Importance Rating: Expertise

Category	Number Giving Each Score					
	0	1	2	3	4	5
EDUCATION						
Bachelor's*	1	1	3	11	9	19
Graduate	2	8	8	29	25	39
	c = 0.90		α = 0.3439		accept	H_0
EMPLOYMENT						
Government	0	6	4	18	15	25
Education	2	3	3	19	12	21
Other	1	0	4	3	7	13
	c = 1.11		α = 0.5751		accept	H_0
ENVIRONMENTAL TRAINING?						
Yes	1	8	5	27	19	35
No	2	1	6	13	15	22
	c = 0.12		α = 0.7310		accept	H_0

* includes one respondent with no university education

The discussion of all results relating to criteria importance is contained in Chapters VII, VIII and IX of the main text of this report.