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COMPREHENSIVE COMPUTER-AIDED ENVIRONMENTAL IMPACT ANALYSIS

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ABSTRACT

Computer-aided environmental impact analysis can be efficient and economical. New regulations from the Council for Environmental Quality have established an operating environment in which computers can be used even more effectively. This paper describes the environmental impact analysis process, examines areas of potential computerization of this process, and describes the current status of computer-aided environmental impact analysis.

Computer-aided procedures can be applied in almost all steps of environmental impact analysis. Three types of information can be systemized: management information, technical information, and quantitative output from analytic models. Existing systems are mostly oriented toward technical information, but current development activities are incorporating analytic models. Maximum efficiency can be achieved if the total process is developed to take advantage of emerging computer technology.

BACKGROUND

During the last few years, the process of preparing an Environmental Impact Statement (EIS) has become an integral element of the Federal (and often state) decision-making process. However, several problems have been encountered with integrating EIS preparation into agency procedure. Initial problems were essentially instances of non-compliance. This was to be expected, since the requirement became law very quickly, and no agency had allocated the staff or resources for preparing EISs. Moreover, executive orders and agency regulations were being issued concurrently with the first attempts at EIS preparation, so there was confusion concerning what the contents, format, and procedural processes should be.

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Eventually, agencies established standardized procedures for performing environmental analyses and preparing EISs. But the completed EIS was often challenged on the grounds that some aspect of the environment which might be affected by the proposed project had not been considered. Attempts to solve this problem produced what could be considered the first systematic approaches to environmental analysis – the checklist and the impact identification matrix. The Leopold matrix was an early technique [1]. A variety of other techniques was soon developed, and the applicability of computer-aided environmental impact analysis became apparent. A review of environmental impact assessment methodologies was made by Jain in 1975 [2].

Another problem concerned the inability or lack of interest in performing environmental impact analysis early in the decision-making process. The EIS, which was intended to be a documentation of a decision-making process, was often an attempt to justify decisions reached arbitrarily (with respect to the environment).

Later problems centered around either a lack of or, surprisingly, an overabundance of environmental information. On one hand, EISs contained long listings of environmental information describing conditions at a project site with little real analysis of environmental effects. On the other hand, potential effects were often described in general qualitative terms, because hard data and analytic techniques were unavailable or unsuited to the operational constraints placed on the impact assessment process.

The need to perform environmental impact analysis early in the decision-making process and requirements for an analytic approach to environmental impact analysis led to a potential increase in computer applications, and the latest Council on Environmental Quality (CEQ) regulations have established an operating environment in which computers can be used even more effectively [3]. The following discussions will outline the EIS process, examine areas of potential computerization of the process, and describe the current status of computer-aided environmental impact analysis.

THE ENVIRONMENTAL IMPACT ANALYSIS PROCESS (EIAP) AND COMPUTER APPLICATIONS

Figure 1 provides a general outline of EIAP steps. Before describing these steps, it would be worthwhile to define the participants involved in the process. The Proponent is the individual responsible for initiating the action, arranging the environmental analysis, and preparing the resulting documentation. The Planner is responsible for carrying out the analysis and preparing the document. Usually, the Proponent and Planner are from the same Agency.

There are three types of consultants. Agency consultants are experts within the Planner's agency who are not normally part of the Planner's Environmental Impact Assessment (EIA) team. These consultants could be temporarily assigned

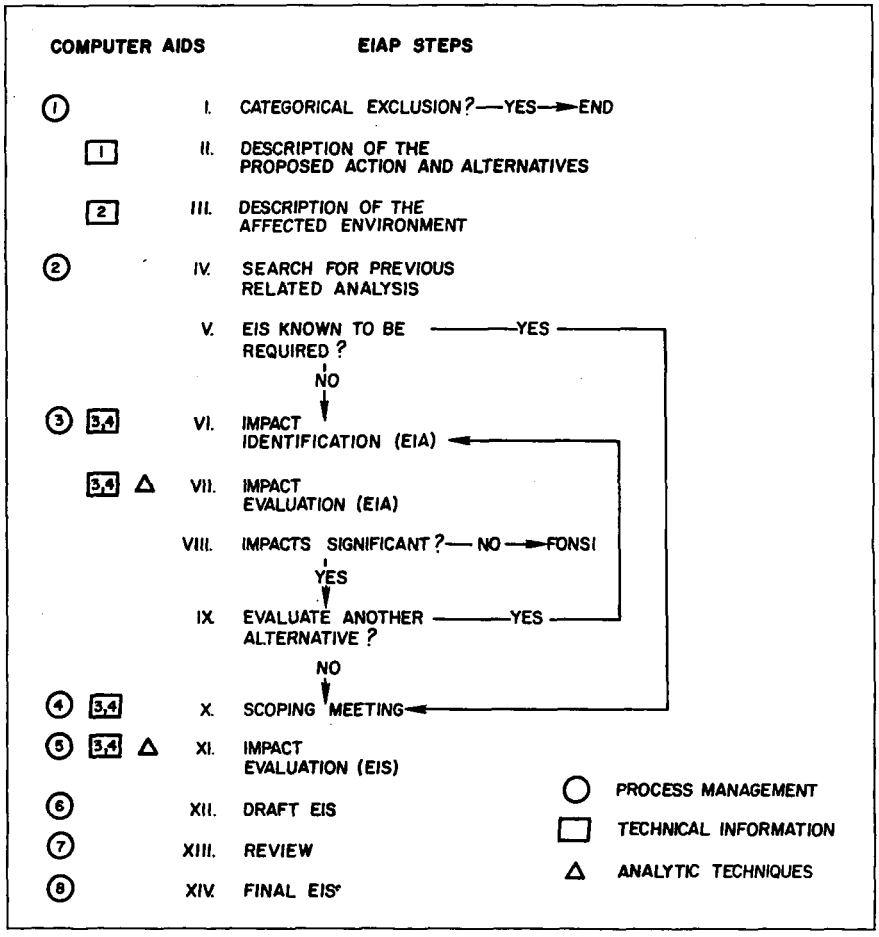

Figure 1. Steps in the EIAP and related computer aids.

to the team when problems arise which require their expertise. Contract consultants come from private firms and academia to perform EIA on a contract basis. Inter-agency consultants belong to a different Federal or state agency than the Planner, but are available upon request to bring their expertise into the process.

Other persons who initially participate in the process as interested observers may become active during certain steps of the EIAP and are categorized under the general title of Environmental Interest Groups. They may come from Federal or state agencies, academia, or the general public.

Reviewers become participants when draft documents have been prepared. Inter-Agency Reviewers are from other Federal or state agencies; Public Reviewers are from the general public.

When the Proponent proposes to undertake an action, the first step is to determine whether the action is a categorical exclusion. A list of categorical exclusions will have been prepared by the Agency and approved by the CEQ. If the action is not excluded, the Proponent initiates the EIAP by preparing a detailed project description for use by the Planner.

The Planner's immediate goal is to determine whether the project or an alternative would result in a significant impact or create environmental controversy. This requires an environmental impact assessment which requires a description of the affected environment. Using the computer, the Planner uses the description of the environment and the project description to search for previous analysis performed under similar circumstances. If information from a previous analysis is available, it can be used for part or all of the required assessment. If early indications are that an EIS must be prepared, the Planner mores directly to that step of the EIAP.

An environmental assessment is conducted to determine the probable effects of the project. Assessment involves impact identification, impact evaluation, and determination of impact significance. The possible results are either a finding of no significant impact, in which case the EIAP ends and the project can proceed, or a finding that impacts are significant or controversy exists, in which case an EIS must be prepared.

A scoping meeting precedes the preparation of an EIS. The purpose of this meeting is to identify the environmental issues which must be considered. Impact analysis is then conducted and a draft document is prepared; when finalized, the document will contain responses to comments made by reviewers of the draft.

Points at which computerization can facilitate the assessment process are identified in Figure 1 by three different types of numbered symbols. Circles represent management information, squares represent environmental technical information, and triangles represent models systems. Each numbered symbol is explained in the following sections.

Management Information

Management information includes computerized techniques and information systems designed to manage the EIAP. Techniques include planning and management routines to more effectively schedule time and control resource use. Information systems are used to maintain communication listings and lists of personnel or other agencies which may become involved in the process.

The EIAP, if carried through preparation of an EIS, can be a complex and controversial process. Few activities bring together such a variety of interests. The EIAP manager must communicate with scientists, public interest groups, and bureaucrats. He must deal with both technical and social issues and must conduct his business in the public eye. Often, the manager is competing with the news media to inform the public about the status of the project. Systematic procedures must be used to effectively control the process.

As environmental impact analysis becomes more sophisticated, it is influenced by the principle of contraction of time [4]. Methods of work, organization of responsibilities, and preparation of decisions are activities which must be performed quickly. Technological advances are decreasing the time necessary to communicate information and increasing the availability of computerized analytical techniques for impact analysis. Impact analysis must keep pace with national environmental awareness. Techniques such as PERT[1] or CPM[2] can help control the timing and interaction of the various EIAP steps.

Expanding EIA requirements are making efficient allocation of scarce time and labor resources essential. Although the CEQ regulations do not establish time limits for accomplishing each step of the EIA process, they do require an agency to indicate the relationship between the timing of the preparation of environmental analysis and the agency's tentative planning and decision-making schedule. Minimum time limits are established for actions to be taken after the EPA receives a Draft EIS. There is a ninety-day minimum decision restraint period and a forty-five-day minimum public comment period. In addition, there is a thirty-day minimum decision restraint period following the release of a final statement.

The following paragraphs describe the numbered circles in Figure 1.

1. *Categorical Exclusions Listing.* Since the Proponent may not be familiar with the EIAP, the first type of information he needs is a list of categorical exclusions. A current list of categorical exclusions can provide this information and preclude further unnecessary effort by the Proponent.

2. *EIS Reference System.* This system would be used to store and maintain a reference library of documents and environmental technical information developed during previous environmental impact analysis. EIA/EIS documents are a valuable resource. The new CEQ regulations permit reference to previous studies. A reference system keyed to type of action, type of impacts determined, or other items could prevent duplication of effort.

A great deal of environmental analysis and data collection has occurred during the last ten years. Unfortunately, little of this information is available for continued reference. Due to personnel changes and agency reorganizations, much of the information has been lost within the agencies. Of course, this information is rarely communicated among agencies. An EIA/EIS document reference system, properly keyed for easy inquiry and widely available, could save the time and money now expanded in duplicated efforts. Such a system could be updated continuously as participating agencies complete studies and accumulate data. The system would reference documents and data and possibly include significant findings; such a system would not store great quantities of text.

[1] Progress Evaluation and Review Techniques.
[2] Critical Path Method.

3. *Agency Consultants Listing.* This type of information system could be designed for in-house use. It would contain information useful in organizing and planning the environmental assessment. Many agencies are critically short of full-time, interdisciplinary expertise such as that required to perform an adequate environmental impact analysis. One way to mitigate this problem is to maintain a record of agency environmental expertise assigned outside of the agency's environmental staff. This type of approach is most applicable to the military, where it is not uncommon to find military personnel who are scientists and engineers assigned to non-technical positions. For example, a tank commander may have a degree in forestry. This type of expertise could be tapped on a consulting basis.

4. *Environmental Interest Groups Listing.* A computerized list of potential scoping meeting participants and their respective environmental interests will help identify persons who should be invited to the scoping meeting.

5. *EIS Consultants Listing.* For impact analysis associated with an EIS, the computerized list of expertise should be expanded to include potential out-of-house consultants and contractors.

6. *Impact Reports Reference System.* With interim impacts reports coming in from a variety of consultants, and communication requirements greatly expanded, systematic procedures are essential. CEQ regulations require that a communications listing be maintained for all sources of technical information concerning the EIAP. Again, a computerized information system could be used.

7. *Clearinghouse Listing.* Federal agencies must coordinate their activities with agencies identified in Office of Management and Budget (OMB) Circular A-95 [5]. Consultation avoids duplication and conflict by providing consistency of planning and insures compatibility of the plans. Clearinghouse responsibilities for environmental planning documents often change. A computerized system can be used to keep the list of state, regional, and local clearinghouse agencies updated so that coordination will be timely.

8. *Review Comments Reference System.* Depending on the degree of public interest, many comments may be received on a draft EIS. An information system would be useful for keeping track of the comments received and the actions taken on them, since CEQ regulations require a response to every comment.

Technical Information

Technical information includes information about the nature of the action and environmental characteristics which will be affected by the action. This information also includes data which indicate or describe the impacts to be expected if the action proceeds.

The following paragraphs describe the numbered squares in Figure 1.

1. *Program/Activity Descriptors.* A well-written project description is essential to the proper completion of an environmental study. The Proponent of a proposed action is usually responsible for developing a description of the proposed action. He may have little experience with the EIAP process or know very little about how detailed a description of the activities is necessary.

Technical information can be prepared which breaks down an agency's projects and programs into detailed activities. Such a generalized list of activities would facilitate communication between Proponents of proposed actions and those who perform environmental analyses.

2. *Environmental Descriptors.* Similarly, the environment can be categorized into areas of environmental technical specialties. Such a categorization scheme would be arbitrary, but useful. It would establish uniformity, help identify important environmental features, and establish common definitions of environmental descriptors. Useful information about environmental features would include a definition of the feature, how the feature can be affected by human activity, and how the feature interacts with other environmental features.

3. *Impact Analysis Information.* Both an activity listing and attribute listing are essential for identifying impacts through a matrix approach. Additional computerized information can be presented in association with matrix intersections to further expand or clarify the nature of the potential impact; e.g., the potential for impact, whether the impact is unavoidable, mitigation techniques, indirect effects, etc., would be useful information.

4. *Environmental Baseline Information.* Environmental impact analysis creates a requirement for detailed environmental baseline information. Water-related information systems, such as EPA's STORET[3] are examples of the extent to which information systems can grow. The environmental data base grows larger with each completed environmental assessment. This growth of information increases the significance of computerization's role in environmental data management.

Models Systems

Analytic models can help systematize impact analysis and provide uniformity and consistency in impact evaluation. Once a model becomes generally accepted, it provides a common basis for impact analysis and can help reduce disagreements about impact magnitude and significance.

Models also bring a degree of interdisciplinary expertise to the process, since

[3] Storage and Retrieval of Water Quality Data – a nationwide computerized information system.

they represent cause-effect relationships developed by experts. The terms "systematic" and "interdisciplinary" are major descriptors of a valid approach to environmental impact analysis.

A "models system" would have three general types of components: analysis guidelines, mathematical algorithms, and supporting data bases. Analysis guidelines provide information for effective model use. The guidelines would relate the various models to the overall impact analysis process and indicate when model use becomes appropriate. They would describe how to access the models and what data are required from the user. They could also provide guidelines on output interpretation.

Mathematical algorithms are the formulations of cause-effect relationships used to predict impact magnitude. They represent the state of available, quantifiable expertise of selected environmental impact analysis topics. They include many models in air, water, economics, and other areas suitable for impact quantification. The problem is to select from available models those with minimum complexity but consistent with appropriate levels of accuracy. Selected models could be incorporated into a system with guidelines and supporting data bases and be both effective and convenient for the user.

When possible, supporting data bases should be developed to reduce the user's data input requirement. Many data are available from existing sources. Examples are U.S. Weather Bureau climatic data, census data, EPA STORET/ BIOSTORET systems, and U.S. Department of Agriculture soils data. User-created data bases could also be accommodated.

Analytic models are essential for determining impact significance. The term "significant" appears often and plays a major role in the EIAP. Scoping meetings identify significant environmental issues. An EIS must be prepared if preliminary analysis indicates that there will be a significant impact, and a section of the EIS must identify and describe these significant impacts. Often, an impact's magnitude must be determined in order to evaluate its significance; models are useful for this task. Once impact magnitude has been estimated, it can be compared with threshold values that represent the levels at which impacts become significant.

CURRENT STATE OF DEVELOPMENT

Certain components of a comprehensive computer-aided impact analysis system similar to that described in the preceding section are currently operational, and work continues on development of other components. The latest development efforts have been concentrated on technical information systems and model systems. Interest in management information systems is more recent. Historically, new systems have been developed to respond to selected needs. For example, the need for an impact identification technique led to the development of the Environmental Impact Computer System

Table 1. Information Systems Content

Management	*Technical*
Planning, Scheduling, and Budgeting	Program/Activity Descriptors
Categorical Exclusions Listing	Environmental Descriptors
EIA/EIS Document Reference	Impact Identification Techniques
Agency Consultants Listing	Impact Evaluation Information
Environmental Interest Groups Listing	Environmental Baseline Information
Contract Consultants Listing	
Inter-Agency Consultants Listing	
Communications Listing	
Consultant Impact Reports	
Text Development	
Clearinghouse Listing	
Review Comments Reference	

described below. Only recently has the concept of computer-aided impact analysis been expanded to include the total EIAP.

Innovative use of computer technology in environmental analysis stems from a unique circumstance – the opportunity to design an operational environmental impact analysis process that will make maximum use of rapidly evolving computer technology. This situation contrasts strikingly with the normal method, in which computer systems are designed to fit an existing operational process.

The following descriptions of recently developed systems indicate the progress in computer-aided impact analysis and capabilities. Systems that are currently operational are described in the documents referenced in the following text.

The current state of development in computer-aided impact analysis can be illustrated by the Environmental Technical Information System (ETIS). Three subsystems of ETIS are currently in use, and work continuse on additional subsystems.

The Environmental Impact Computer System (EICS) uses the matrix approach to identify potential impacts [6]. It provides information relating to the first four items of technical information identified in Table 1.

The Computer-Aided Environmental Legislative Data System (CELDS) is a technical information system that supports impact identification and evaluation at all levels [7]. This system provides informative abstracts of pertinent Federal and state environmental laws and regulations. CELDS also lists local agencies having clearinghouse responsibilities under OMB Circular A-95. This information

is presented as a subsystem called the Clearinghouse Information System (CHIS).

The Economic Impact Forecast System (EIFS) is typical of a model system [8]. The model is supported by a data base of census information and provides estimates of economic impacts. The system provides various report formats of selected census data. EIFS provides a technique for determining the significance of economic impacts through use of rational threshold values (RTV).

Work continues on refining operational technical information systems and developing air and water models systems. An Early Warning System (EWS) is being developed to help identify major impacts of all types early in the decision-making process. Of the thousands of potential impacts that could result from a project, relatively few are important enough to necessitate modification or termination of a project; however, in these cases, an early indication of such problems can prevent a great deal of wasted planning effort.

Environmental baseline information is a problem area that is still not completely resolved. EICS identifies potential impacts, but the responsibility for providing information to verify EICS output rests with the user. The Baseline Information System (BLIS) is being developed to provide EICS users with site-specific data or to identify possible sources of such data. Directories of regional experts and conservationists and information regarding existing data management systems are being compiled.

In the ongoing development of ETIS, a conscientious effort is being made to use the latest available computer technology. It is the author's opinion, based on experience with Army military environmental impact analysis, that any computer system which requires more effort from the user than taking a book from the shelf, glancing over the index, and turning to an item of interest, may rarely be used. Appropriately designed computer systems need not be difficult to use. ETIS operates on a PDP 11/50 with two 300-megabyte disks and uses the programming language C. Its operating system is UNIX.

CONCLUSIONS

Computer-aided procedures, which can help simplify and control the complex process of environmental impact assessment, can be applied in almost all steps of the EIAP. Three types of information can be systemized: management information, technical information, and quantitative output from analytic models.

Some components of a comprehensive computer-aided impact analysis system are already operational. Existing systems are mostly oriented toward technical information, but current development activities are incorporating analytic models. Maximum efficiency can be achieved if the total EIAP is developed to take advantage of emerging computer technology.

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