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ANTICIPATING ENVIRONMENTAL PROBLEMS– A SYSTEMS APPROACH*

KAN CHEN

PAUL APPASAMY

University of Michigan
Ann Arbor, Michigan

MICHAEL DONAHUE
Center for the Great Lakes
Chicago, Illinois

JOHN REUSS
U.S. Environmental Protection Agency
Washington, DC

ABSTRACT

The Environmental Problems Anticipatory Systems (EPAS) was developed as part of a cooperative research effort between the University of Michigan and the U.S. Environmental Protection Agency. The purpose of the research was to develop a systematic procedure for the anticipation of emerging environmental problems. The system was developed over a three-year period during which it was designed, refined, and tested. EPAS uses a systems approach involving experts from different sectors to identify and analyze emerging environmental problems. The major subsystems of EPAS involve monitoring, analysis, selection, and scoping. The research effort indicates that EPAS is an operational and tested approach that produces timely and cost-effective information for anticipating emerging environmental problems in a systematic manner.

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INTRODUCTION

The last two decades have witnessed the development of an immense literature on the use of forecasting, projecting, modeling, and other techniques in anticipating future problems. Multidisciplinary efforts utilizing "open systems" approaches and a variety of tools and indicators have proliferated in both the public and the private sectors. More recently, there have been attempts to utilize such information in improving the management of public and private organizations. The rapid changes in technology and information make it imperative for managers in government and industry to have the capacity to anticipate future problems and issues if they are to be effective. Environmental issues represent one set of such problems, within the universe of problems with which managers and policy makers have to grapple. The integration of environmental concerns in major investment decisions has become institutionalized as a result of programs developed in the sixties and seventies. However, the field of environmental management is no longer restricted to the past emphasis on pollution abatement. Measures to manage resources and improve the quality of life command increasing attention. Policies that are anticipatory and preventive are receiving increased emphasis, reinforcing policies that are essentially reactive and curative [1].

The process of anticipating emerging environmental problems has to a large extent occurred on an *ad hoc* basis. It has become increasingly clear that there is a need to develop a systematic procedure for this purpose. The Environmental Problems Anticipatory System (EPAS), which was developed as part of a cooperative research effort between the University of Michigan and the U.S. Environmental Protection Agency, is one attempt to meet that need. This article provides a brief description of EPAS, and some initial experiences in the development and testing of the system.

BACKGROUND

Among the goals of the U.S. Environmental Protection Agency (EPA) is the mandate to identify and address future environmental problems in a manner that is compatible with the long-term economic and social goals of the nation. This mandate entails the identification, definition, and assessment of emerging environmental problems and the promotion of mission-oriented basic research to provide policymakers with the capacity to anticipate and address these emerging problems in an informed and expeditious manner.[1]

The Agency's continued commitment to the enhancement of its anticipatory efforts culminated in a cooperative arrangement with the University of

[1] Environmental Research, Development and Demonstration Authorization Act of 1978 (Public Law 95-55).

Michigan. The university staff of the Program in Technology Planning and Assessment (College of Engineering) was directed to examine the Agency's existing anticipatory program and explore means by which environmental indicators could be used to systematically prepare a comprehensive candidate list of future environmental problems and screen the candidate list to identify those warranting further analysis. The term "environmental indicators" was defined as *the range of qualitative clues and quantitative measures which facilitate the anticipation and visualization of potential environmental problems.* The three-year study culminated in the development and testing of EPAS–The Environmental Problems Anticipatory System. EPAS is an interdisciplinary anticipatory procedure which draws upon relevant trends and human expertise to permit the identification of, and subsequent assessment of, future environmental problems. Four principal tasks were carried out in the development of EPAS:

1. *System Design:* A conceptual framework for exploring the origins of environmental problems was posited, resulting in the identification of economic, social, scientific and political/legal domains in which relevant driving forces need to be monitored. Three case studies (indoor air pollution, recombinant DNA technology, and electric vehicles) were conducted to further explore the "domain analysis" approach and subsequently refine the conceptual framework.
2. *Network Identification:* Over the study period, extensive interviews were conducted with the strategic planning and environmental staffs of numerous public agencies and private sector businesses and organizations. Multiple objectives of these interviews included the exploration of various anticipatory techniques; solicitation of input on the development of EPAS; and the construction of a monitoring network to be utilized when EPAS became operational.
3. *Indicator Development:* Networking and literature review approaches were employed to generate an extensive list of environmental indicators.
4. *System Application:* The testing and refinement of EPAS is an ongoing and integral component of the study effort. The case studies previously mentioned served the purpose of initial testing. A pilot workshop involving EPA and project staff tested the EPAS procedure more fully in the first year and included the use of structured group techniques to screen and prioritize future environmental problem "candidates" for possible *microassessments* by the Agency.[2] A second workshop involving private sector representatives was conducted in the second year, permitting further refinement of the EPAS procedure. Two

[2] A microassessment is a small scale environmental assessment of a problem, the potential severity of expected impacts, and the identification of a few policy alternatives.

microassessments were conducted in the third year on problem candidates identified in the two workshops. Current research efforts are directed towards refining and evaluating the system.

SYSTEM DESIGN

Environmental problems are caused by *driving forces* in the economic, social, and political domains, as well as from developments in science and technology. There is a complex set of interrelationships among these four domains which results in the emergence of environmental problems. This concept was tested using three case studies. The case studies involved brief environmental assessments of indoor air pollution, recombinant DNA technology, and electric vehicles. These assessments were given to *experts* in each of the four domains. They concluded that each of the three problems could have been identified earlier if developments and trends in the four domains had been monitored in a collective fashion.

In order to anticipate environmental problems in a *systematic* manner, it is necessary to *monitor* the four domains. The information generated by monitoring should be amenable for *analysis.* It is necessary, therefore, to reduce broad concerns to specific indicators that can be integrated in a workshop format. Using appropriate criteria, this information can then be used to identify and *select* specific problems for further study. The selected problems are then *scoped* through a microassessment process to determine if the problem merits further attention. Thus, EPAS essentially involves four *subsystems* as shown in Figure 1:

- *Monitoring* the scientific, economic, social, and political domains to detect events and trends that might coalesce into environmental problems.
- *Analyzing* these quantitative and qualitative clues in a workshop format with the involvement of representatives from government, industry, public interest groups, and the scientific community to identify a candidate list of emerging environmental problems.
- *Selecting* a manageable set of environmental problems from the candidate list using a set of appropriate criteria by involving the same group of people at the workshop.
- *Scoping* the selected problems through an assessment process with the help of experts, and a peer review process.

Before describing each of the subsystems in detail, it may be worthwhile to briefly review the approaches used by other organizations to identify future environmental problems.

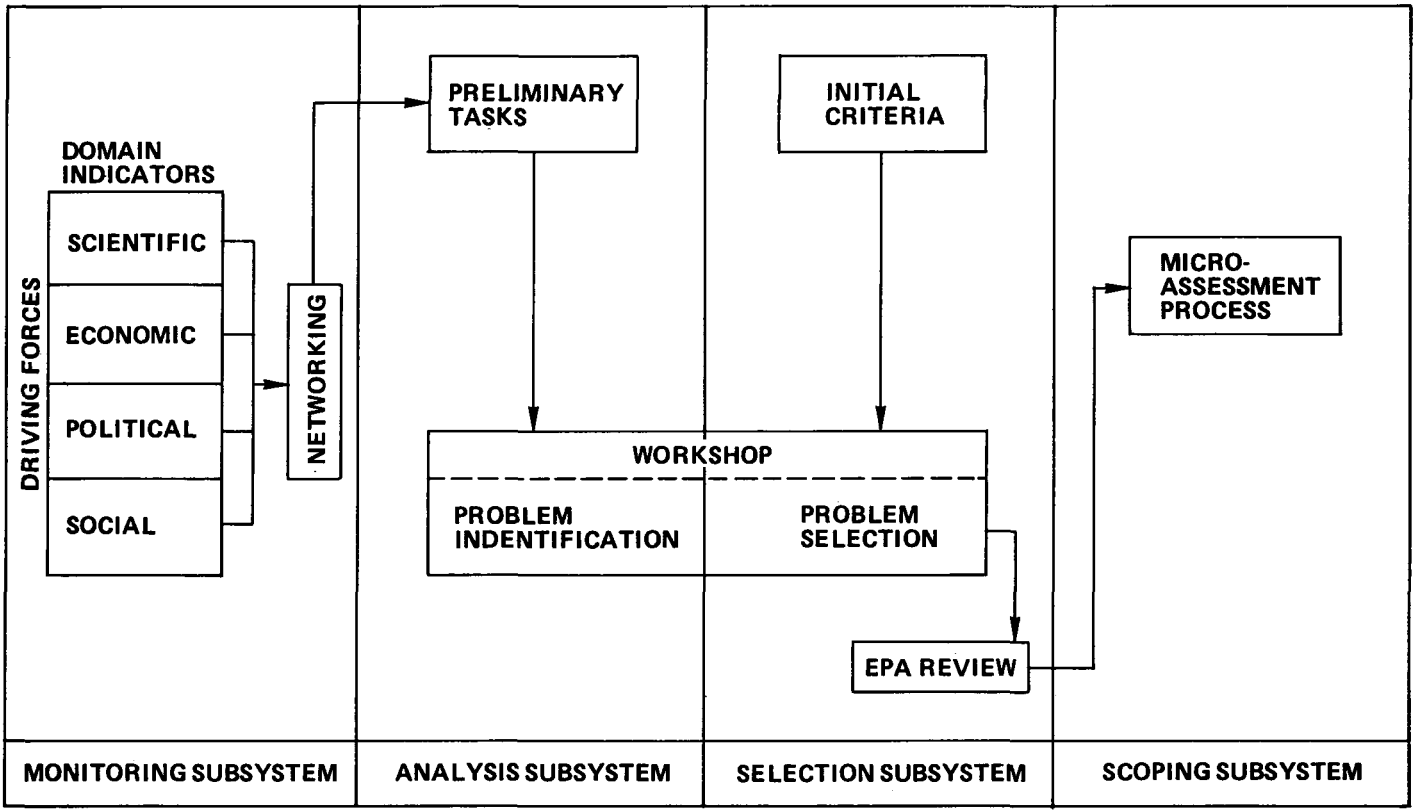

Figure 1. Environmental Problems Anticipatory System (EPAS).

During the last few years, there have been attempts by several organizations to identify and prioritize major current and future environmental issues. The Conservation Foundation reviewed six of these studies, including the University of Michigan study, and provided a summary report in *The Conservation Foundation Letter* and in *State of the Environment: An Assessment at Mid-Decade.* The issues identified in these studies ran the gamut from regional to global, and from substantive to institutional. However, there appeared to have been rather broad agreement on the most significant and difficult problems [2].

The studies reviewed in the Conservation Foundation reports essentially surveyed scientists and other knowledgeable people for their expert, subjective opinions. The studies included the results of two workshops conducted as a part of this research (i.e., the development of EPAS). However, none of the other studies required the experts to use a common interdisciplinary base of information for their predictions. The major emphasis of EPAS is that the workshop participants integrate the interdisciplinary information prior to making their predictions. This process is aided by using lists of indicators, background papers, and presentations. The conceptual model visualizes the group of workshop participants as processors and analyzers. They receive common information which they process using their background and experience. They also analyze the information in an interdisciplinary setting guided by structured group techniques. The result of the interaction is a list of emerging environmental problems. Furthermore, EPAS has an assessment or scoping component that provides a substantive analysis of the importance of the selected problems. The scoping process also provides feedback to the monitoring subsystem on driving forces and indicators.

A more quantitative approach was used by Leitch and Leistritz at North Dakota State University in a study of environmental issues in the Great Plains and Rocky Mountain States. They conducted a Delphi-type survey and a consensus-building workshop. They conclude that: "the Delphi method appears to be a powerful and flexible tool for evaluating emerging environmental issues" [3]. Researchers at the University of Oklahoma used a causal model similar to EPAS in performing a "regional environmental assessment for policy making and research and development planning." The conceptual framework that they developed included characterization of regional trends, identification of environmental problems, and analysis of policy alternatives [4]. The Oklahoma model differs from EPAS in two ways. First, the emphasis of their assessment is regional rather than national. Second, the methodology employed was a regional planning approach, rather than the use of workshops and experts. Thus, EPAS combines the conceptual flavor of the Oklahoma study and the methodological aspects (except that it is not quantitative) of the North Dakota study. Also, EPAS has a unique quality in that it uses "indicators" within an interdisciplinary framework of domains.

SYSTEM DESCRIPTION

Monitoring Subsystem

As mentioned earlier, the purpose of monitoring is to identify the trends and developments in each of the domains which coalesce in an interrelated manner to create environmental problems. Thus, it is necessary to monitor each of the four domains–economic, social, political, and science and technology. In EPAS, we suggest that this be done through a networking process. Such a process should include traditional literature review as well as personal contacts by telephone, interviews, and informal discussions with key experts, decisionmakers, regulators, and business people.

The review of the literature should include sources of information in the four domains that provide qualitative or quantitative clues regarding the emergence of environmental problems. The personal contacts should be with representatives in government (federal, regional, state, local), the scientific and research community, the private sector, interest groups, and possibly international agencies or organizations.

In testing the monitoring subsystem we used three techniques. First, we interviewed planning and environmental staffs of numerous public agencies and private sector organizations. These individuals helped us in the development of the system and also agreed to participate in an information network. Next, we conducted a review of literature sources suggested by these individuals and by our "domain" experts and prepared lists of indicators in the four domains. Last, we conducted telephone and mail surveys of selected individuals to obtain their views on emerging environmental problems. The information generated by these efforts were used as the basis for further analysis.

Analysis Subsystem

The next step is to *analyze* the information provided by the monitoring subsystem using an interdisciplinary approach. Numbers and graphs supplied by the monitoring subsystem do not spell out environmental problems automatically, but provide rich clues for problem identification by knowledgeable and forward-looking people.

The primary mechanism to carry out the analysis is an interactive workshop that will involve thirty to forty participants selected from the diverse group of people identified in the networking process. However, the workshop should be preceded by three preliminary tasks. First, a list of *indicators* of environmental problems needs to be culled from the monitoring information. Second, a *survey* of participants and resource people should be conducted to learn about their concerns about environmental issues, background and knowledge bases. The survey could be done by telephone interview or through questionnaires. The concise summarizing of the results will provide a useful digest on the diversity

of opinions and analysis that could be used in the design of the workshop. Lastly, some analysts and practitioners should be commissioned to prepare *background papers* to assist the staff and project participants in understanding the issues and alternatives.

The objective of the workshop is two-fold:

1. to assess, evaluate, and improve on a set of qualitative and quantitative indicators developed earlier for use in predicting future problems by using structured group techniques;
2. to identify as many potential environmental problems as possible from a set of *stimuli* (e.g., indicators, presentations, discussion) using structured group techniques. These techniques are used to facilitate group interactions in a creative yet focussed manner, and to avoid dominance of interaction by a few individuals.

In 1981 and 1982 two workshops were conducted at the University of Michigan. The first workshop was essentially a pilot one using EPA officials and project staff. The second workshop involved several representatives from the environmental staffs of private corporations. Examples of environmental problems that emerged from each of the workshops are given in Figures 2 and 3.

Selection Subsystem

The next logical step after identifying a candidate list of future environmental problems is to *select* those problems which have a high probability of becoming significant environmental issues. EPA could then carry out further research through microassessments of the selected problems.

The process of selection is also done at the same workshop, mentioned earlier, but at a different session. The process involves the use of criteria in selecting topics from the candidate list of problems. The initial criteria can be classified in three categories: 1.) Feasibility, 2.) Desirability, and 3.) Operationality.

The first step in the workshop is to use structured group techniques to refine the criteria within the three categories. The next step is to apply the criteria to the identified topics. In selecting problems based on such criteria, participants might also be asked to tie problem identification back to specific indicators (quantitative if possible). Such documentation would aid EPA in justifying and substantiating the identification of particular problems to evaluators or outside groups. The outcome of the selection process is a recommended list of environmental problems which could be used in carrying out *microassessments.*

The final selection of topics for microassessments would be done in-house by EPA, using the recommendations from the workshop. Based on the available funds, EPA could allocate funds for each topic, assuming a range of $5,000 to $30,000 per assessment. EPA might wish to use other in-house criteria

- Increases in environmentally caused disease rates
- Loss of prime agricultural land
- Ocean vs. land disposal
- Automation accelerating industrial electrification[a] (pollution from power plants)
- Interbasin water transfers to industrializing regions
- Accelerated degradation in developing countries
- Unpredictable natural disaster effects
- Proliferation of new chemicals and biological organisms
- Environmental effects of another war(s)—limited or general
- Concentration of industrial toxics around urban areas

[a] Topic selected for microassessment (with some modification).

Figure 2. Examples of Emerging Environmental Problems. Developed from Nominal Group Technique—1981 Workshop.

- Capital budgeting
- Economic impact of uniform standards
- Mediation methodologies
- Alternative management models
- Perceived versus calculated risk[a]
- Perception of health and environmental risks in energy technologies
- Loss of groundwater availability
- Water resource utilization: Competing use
- Incentive for business involvement

[a] Topic selected for microassessment

Figure 3. Examples of Emerging Environmental Problems. Nominal Group Technique for Identifying Topics—1982 Workshop

in narrowing down the recommended list. After the final decisions on topics have been made, the actual implementation of the microassessment could be carried out.

Scoping Subsystem

The implementation of the microassessment is essentially contained in the scoping subsystem. *Scoping* involves determining the magnitude or scope of the environmental problem and the appropriate next step for EPA to take. There are four aspects to scoping:

1. To determine whether a potential environmental problem is actually likely to occur;
2. To determine whether it is likely to be a significant problem;
3. If it is significant, what additional research on the problem should be given a high priority; and
4. To determine whether addressing the problem is within EPA's mission.

The tasks that are involved in *scoping* include choice of funding level; selection of experts for microassessments; preparation of preliminary drafts by experts; peer review of the microassessment; interdisciplinary review; and final review by EPA.

From the topics generated at the two workshops, EPA used their internal criteria to select two topics for microassessments.

1. Discrepancies between perceived risk and calculated risk.
2. Impact of robotics on utility load curves.

Experts were identified at the University of Michigan to carry out the microassessments. Each of the experts was given specific guidelines and asked to prepare a ten to fifteen-page draft report addressing policy issues and impacts. After the report was submitted to project staff to ensure conformity with the guidelines, it was then provided to two external reviewers—one from the university and one from the private sector. The reviewers were asked to provide their comments at a two-hour meeting in oral form to the experts and project staff. The expert in each case responded to the comments by the reviewers by clarifying issues and by agreeing to include new ideas, delete or change parts of the report, based on the comments provided at the meeting. The revised reports were then reviewed by project staff and sent to EPA.

CONCLUSIONS

During the conduct of the study, a number of system characteristics which complement and enhance the anticipatory process were defined. EPAS was designed to incorporate as many of these characteristics as possible. Consequently, EPAS is a flexible and cost-effective interdisciplinary process, readily adaptable to changing anticipatory needs and budgetary constraints. It is both comprehensive and participatory, given its sensitivity towards environmental problems emerging from multiple domains, and the involvement of knowledgeable and forward-looking people from multiple sectors. Finally, the quick turnaround time on assessing selected problems enhances the ability to take timely actions upon emerging problems and issues, rather than react to existing ones. While EPAS was designed originally to meet specific needs of the U.S. Environmental Protection Agency, it could with some modifications be used by environmental agencies at other levels of government or in other countries.

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Direct reprint requests to:

Paul Appasamy
Program in Technology Planning
and Assessment
Room 4520, East Engineering Building
The Universtiy of Michigan
Ann Arbor, MI 48109