



Usable Knowledge for Managing Responses to Global Environmental Change: Recommendations to promote collaborative assessments and information systems

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Belfer Center for Science & International Affairs

**Usable Knowledge for Managing Responses
to Global Environmental Change:
Recommendations to promote collaborative
assessments and information systems**

**Thomas M. Parris, Charles A. Zracket, and
William C. Clark**

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PREFACE

In January 1993, Harvard University's Center for Science and International Affairs and the Consortium for International Earth Science Information Network (CIESIN) initiated a joint project to conduct a study of global environmental change information policy. The project convened the Commission on Global Environmental Change Information Policy — a distinguished group of twenty-one national leaders in environmental policy analysis, Earth systems science research, and information systems — to formulate a set of concepts and policies that will promote the effective and widespread use of emerging knowledge about global environmental processes by policy analysts in government, industry, academia, and other non-governmental organizations. This report is the product of the Commission's deliberations.

The Commission members were selected to cover three representation matrices. The policy analysis community matrix had two dimensions: geographic scale of the analysis, and institutional perspective. The Earth systems science matrix also had two dimensions: discipline, and major research program. Finally the information systems matrix was broken down into three components: information technology, information policy, and information services.

The Commission met in a series of four workshops, beginning in May 1993 and ending in September 1994. Several federal officials involved with the US Global Change Research Program attended the workshops as active observers.

This paper draws extensively upon the comments and advice of the Commission members throughout this process. However, responsibility for its content lies with the named authors. Individual Commission members have not approved the text that follows.

FOREWORD

The recent agreement in Kyoto underscores the critical relationship between scientific understandings of global environmental change and national, international, and even local policies. For the first time, representatives of the nations of the world agreed to reduce their future production of greenhouse gases in order to limit the damage that human activities can cause in the Earth's atmosphere. At the core of the agreement was a belief by policy makers, who may have had little scientific training themselves, in scientists' assessments of the causes and consequences of changes in the global atmosphere. Because those changes can neither be seen nor felt as yet, and because the consequences of the Kyoto agreement could have significant economic implications for many nations, this policy response to scientific research was particularly significant. The Kyoto agreement is just the beginning. There will be a growing need for scientists and policy makers to work together on environmental issues in the years ahead.

The issue of scientific communication and its role in public policy is one that has engaged social scientists for many decades. It has become a matter of central importance again with the emergence of global environmental change on the international policy agenda. However, the nature of the problem has changed from earlier discussions. The evolution of information technologies over the past decade has radically transformed both the scale of information resources available to scientists and policy makers and the ways that information is obtained, managed, and disseminated. The Usable Knowledge project conducted by the Harvard Center for Science and International Affairs thus begins to lay a foundation for constructive interactions between these two communities by thinking through the difficult and complex issues related to the access and use of information in policy making on global environmental change.

In focusing on scientists and policy makers, we must not forget, however, that in a democracy, public opinion also plays a critical role in policy. The strength of public opinion will undoubtedly be seen in the coming year as both policy makers and the public respond to the Kyoto agreement in the United States. In addition to the fact that many people have little knowledge of science, communication of scientific information to the general public is complicated by two factors. One is the almost ritualistic presentation of two sides to every issue in contemporary journalism. This practice requires that opposition to the scientific consensus be presented with the same seriousness as the consensus position, breathing new life into discarded scientific ideas under the guise of presenting a "second opinion" to balance news stories. Second, we should not underestimate the importance of brute force public relations campaigns against public policy that threatens the economic livelihood of key industries. The terms of the public debate on Kyoto will be far reaching and will be influenced as much by professional communicators with little knowledge of science as by scientists. For this reason, communicating science to the general public is as much a challenge—and as important—as communicating with policy makers. Because of its importance, it could easily constitute the next chapter in this important essay into usable knowledge.

Roberta Balstad Miller
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1. INTRODUCTION¹

The need to better integrate research with policymaking across a broad spectrum of social and economic issues is now widely recognized. John H. Gibbons, Director of the Office of Science and Technology Policy, summarizes the challenge: “Research has to be directed toward answering current and anticipated policy questions; and policy has to respond to new research results.”² Clearly, this statement does not mean that all research should be driven by today’s policy questions, nor that policy should be decided exclusively on the basis of the latest research results. However, it does highlight a general need for greater interaction and sharing between these two very different activities and their associated communities. Satisfying this need is a necessary condition for improved formulation, execution, and evolution of policies designed to address important public issues.

Nowhere is the need for integrating knowledge with action greater than in the area of global environmental change — a field with linkages to a broad range of policy issues including climate change, biological diversity, natural resource use and management, air quality, water resources, toxic and hazardous substances, and natural disaster reduction. The combination of long time horizons, expansive spatial scales, large uncertainties, and the pervasiveness of causal social behaviors makes these issue areas particularly difficult. These challenges are compounded by the difficulty of effectively managing and making use of the vast quantities of information being collected about the global environment.

This report recommends policies and concepts to promote more effective and widespread interaction between the global environmental change research and policy analysis communities. The Carnegie Commission on Science, Technology and Government stated that, “Assessment is the bridge between science and policy.”³ The US Global Change Research Program (USGCRP) has defined the purpose of its “assessment” element to:

“provide a function for coordinating and reporting the current state of knowledge about the implication of global change for national and international policymaking activities. This new assessment function covers a broad spectrum of global and environmental issues. . . . Building on the new assessment component, the goal of this program expansion is to enable the U.S. Government to conduct end-to-end (integrated) assessments of global change issues upon which sound policies can be identified, adopted, implemented, and maintained at regional, national, and international levels.”⁴

This report focuses on the types of institutions, processes and information systems that would improve local through multinational assessments of global environmental change, its ecological and socioeconomic consequences, policy options, and past management performance. These assessments are, and will be, performed by policy analysts and decision-makers in government, industry, academia, and the general public.

The remainder of this report is divided into two major sections. The first section, “Better Assessments of Global Environmental Risks, Policy Options, and Past Management Performance,”

presents a set of institutional and procedural characteristics that will promote more useful assessments of global environmental change. The second section, “Collaborative Information Systems for Linking Knowledge to Action,” describes a set of design concepts and principles for a complex of interdependent information systems that will support these institutional and procedural characteristics by more effectively sharing information among the many people who produce and consume assessments of global environmental change.

2. BETTER ASSESSMENTS OF GLOBAL ENVIRONMENTAL RISKS, POLICY OPTIONS, AND PAST MANAGEMENT PERFORMANCE

The Commission was originally convened to make recommendations about information systems that would enable improved use of emerging scientific information about global environmental change by policy analysts and decision-makers in government, industry, academia and other non-governmental organizations. Early in our deliberations, we concluded that a focus on information systems was necessary, but not sufficient to improve policy-relevant assessments of global environmental change. While one could indeed take steps to improve the unidirectional flow and processing of information from source (e.g., a satellite-based sensor) to end-user analyst (e.g., a congressional staff member), this alone would not significantly improve the quality or utility of assessments. “Intelligence” in the form of analysis and interpretation must be added to data and information as it moves back and forth between the two communities. Therefore, the Commission began its deliberations by reviewing the successes and failures of past efforts to perform major government-sponsored assessments of large-scale environmental issues.⁵ Several important findings and recommendations about assessments that are useful in the policy process emerged from this examination:

2.1 Assessments benefit from broad participation

Conventional definitions of assessment assume a bi-polar world with scientists on one side and policy or decisionmakers on the other (see Figure 1). In this model, the role of assessment is to convey the consensus of the scientific community to a well-defined set of decisionmakers with clearly defined questions. While this model may be effective in contexts such as military planning and national security policy, it appears to be deficient in several respects when it comes to assessments of global environmental change.

Global environmental change is defined, in part, by its long time horizons. As time passes, the framing of the policy debate will change. For instance, the issue of climate change has at different times been framed in terms of nuclear winter, agricultural productivity, and fossil fuel consumption.⁶ Similarly the issue of stratospheric ozone depletion has been framed in terms of high altitude aircraft, aerosol spray cans, and phasing out the production of chloroflourocarbons (CFCs). As the framing of the debate changes, so too will the policy community’s demand for scientific advice. Therefore, *assessments should be performed iteratively over relatively short time frames. They should also be structured to serve as a bi-directional vehicle for both delivering advances in scientific understanding to the policy community, and for*

communicating changes in the state of policy and related debates to the scientific community (see Figure 2).

Second, in the open and pluralistic context of American environmental politics, the fact that a group of scientific experts can reach consensus is generally not a sufficient condition for policy makers to decide on a course of action. Changes in policy require broad public understanding and support. After all, the decisionmaking community for global environmental change is extraordinarily diffuse. In addition to highly focused international negotiations and national legislative and regulatory decision processes, important decisions are made at regional, state, and local scales by both public and private actors. Regional water authorities plan the construction of dams and reservoirs. States regulate energy and related utilities, transportation, land-use and construction. Cities and towns make coastal-zone land-use and investment decisions. Industry makes process and product design decisions. Banks approve mortgages for the purchase of agricultural lands. Individual citizens make decisions about which goods to purchase, how to heat their homes, and where to take vacations. The people who make these decisions make both implicit and explicit assumptions about environmental and social boundary conditions and how their actions will affect and be affected by changes in these conditions over time. Therefore, *the assessments should be structured so they are transparent and accessible to the diverse set of individuals and organizations with interests in the science and policy of global environmental change* (see Figure 3).

Efforts designed to reach a broad consensus by reviewing and synthesizing the results of multiple independent analyses will be more effective if they explicitly engage scientific representatives from the communities with stakes in the policy outcomes in the assessment process. This involvement will help to remove potential biases in the assessment findings and increase the likelihood that the findings will be accepted and acted upon by decision-makers. These efforts often fail because their executive summaries attempt to gloss over conflicting interpretations of the available science.⁷ If no consensus can be found, these efforts should not hesitate to report the best available arguments for and against alternative interpretations of the science. Above all, executive summaries must be accurate and non-selective with respect to the body of the full reports. *Sponsors of assessments should not judge their efficacy by the degree to which they reach consensus. Well structured disagreement is as useful to the policy process as consensus.*

2.2 Useful assessments are intensely collaborative activities

Global environmental change is a complex phenomenon. Assessments of this phenomenon are valuable precisely because they draw upon the knowledge and expertise of diverse intellectual, policy, and other interested parties. Successful assessments will require effective collaboration occurs across several sets of boundaries which include:

- *disciplinary boundaries*, such as atmospheric chemistry, terrestrial ecology, economics, and anthropology;
- *jurisdictional boundaries*, such as national governments, federal agencies, and state and local government agencies;

- *stakeholder interests*, such as industry, labor, consumer, environmental and media groups;
- *issue areas*, such as climate change, biodiversity, ambient air quality, toxic and hazardous substances, natural disasters, water resources, and resource use and management; and
- *types of assessment*, including assessments of environmental risk, policy options, and performance of previously implemented policy regimes.

Sponsors of global environmental change assessments (e.g., Federal agencies, foundations, corporations, and public interest groups) should use these “axes of collaboration” as part of their selection and evaluation criteria. This will force individual assessment efforts to more carefully define the boundaries of their study, identify key individuals who need to participate in the process, and the mechanisms through which they will interact. Institutions, processes, and information systems designed to support assessments must accommodate and encourage these forms of collaboration.

Sponsors of assessments should also acknowledge that there is a shortage of people who have the breadth of training required to effectively work across and integrate these axes of collaboration. They should work with educators and employers to establish an attractive training and professional career path for would be assessors. The emergence of successful educational programs in Environmental Science and Public Policy (e.g., Harvard University), Engineering and Public Policy (e.g., Carnegie-Mellon University), and schools of Environment (e.g., Duke University) demonstrate that significant progress has been made on this front. However, the recent demise of the Office of Technology Assessment casts doubt that the Federal Government shares this commitment.

2.3 Assessments are more likely to be trusted by, and useful to, the policy community and the public at-large when multiple independent efforts arrive at mutually reinforcing conclusions using different methodologies

We are still learning to assess the implications of global environmental change on public and private policies. There is no single method that will produce a completely satisfactory analysis. Rather, we should encourage multiple independent analyses that can complement, compete and learn from one another. The natural tension that exists between centralized analysis and planning efforts, and narrower decentralized implementation efforts is productive and should be encouraged.⁸ Large-scale multinational assessments such as those performed by the Intergovernmental Panel on Climate Change and the Framework Convention on Climate Change serve to focus attention on the issues and synthesize broadly conceived plans of action. In contrast, relatively small-scale local assessments such as the analysis of coastal zone setbacks performed by the city of Charleston, South Carolina, and of energy efficiency programs performed by the city of Portland, Oregon, serve to test the viability of specific decentralized implementation options. As part of this multiple assessment approach, specific social actors (e.g., the insurance industry, hybrid crop developers, industrial sectors, public health officials, government officials at all levels) should be encouraged to conduct assessments of global environmental change that are tailored to

their particular decision-making needs. These smaller-scale efforts will improve the foundations upon which the large-scale efforts are built; and will, in turn, take the results of large-scale assessments and apply them to specific problems.

The US Federal Government should adopt a multiple and pluralistic approach to its assessments of global environmental change. It should avoid the temptation of centralizing all of its assessment efforts under a unified program management and design philosophy with the goal of producing an “ultimate” assessment. Such an approach would prematurely limit the range of analytic methods that can be effectively used in these assessments. An approach that supports multiple independent assessments with different methodologies and multiple inputs will eventually have far greater influence with the public and decision-makers. Recent grant competitions by the National Science Foundation should be applauded for following this approach.

A fraction of the total global environmental change assessment budget should be devoted to improving the underlying analytic methods. This will promote long-term improvement in the overall quality of these assessments. Again, the National Science Foundation should be applauded for its efforts to fund methodological research.

2.4 Assessment is necessarily an information-intensive activity

People and organizations perform policy-relevant assessments on the basis of their understanding of information readily available to them. Important information for environmental decision-making is collected, analyzed, and held by numerous institutions worldwide. This information includes collections of previous analyses and assessments, and natural and socioeconomic data. Unfortunately, the dispersion of information and expertise makes it difficult for all but the most sophisticated and well equipped analysts to acquire, understand, and make effective use of the information potentially available to them. Efforts to reduce these barriers to access will enable more frequent, complete and timely assessments by all classes of users.

The multiple and pluralistic assessment approach outlined above must be complemented with periodic reviews and a strong information management program to encourage collaboration, competition, transparency, and learning between individual efforts. These reviews should involve representatives from the sponsor, scientific, policy and stakeholder communities. They should evaluate the scientific state-of-the-art, the current and likely policy needs, and establish a recommended agenda for future assessments. The information management effort should strive to enhance transparent access to individual assessments and their associated analytical methods (e.g., integrated assessment models of climate change).

3. COLLABORATIVE INFORMATION SYSTEMS FOR LINKING KNOWLEDGE TO ACTION

The need to promote broad policy analyst and decision-maker use of information about environmental change is well recognized by both the research and policy communities. It is an issue with technical, institutional and policy components. It is also a special case of the broader issue of how best to provide broad access to and promote the use and sharing of scientific and technical

information in general -- a topic with a long history. "Between 1947 and 1980, the [US] government published approximately 40 major reports on the importance of scientific and technical information and the appropriate Federal role in encouraging that management and use of scientific and technical information."⁹ Fulfilling this need is important because our investment in better information and new knowledge for policy purposes will not be realized until it is used for decision-making, and because of our relatively poor record in performing this function in the past.¹⁰

The Commission envisioned a self-organizing complex of autonomous, interdependent information systems that enable more effective assessments of global environmental change. These interdependent systems, centers, and communications networks would be both government and market-driven. "Information systems form an integral part of the fabric of modern organizations. In information-intensive businesses they are the fabric. They help it determine how work gets done. They often help determine who does it. Sometimes they help define what the work is."¹¹ Therefore, this complex of information systems that is emerging to support analysis of global environmental change should evolve in a manner that is consistent with and encourages the participatory, collaborative, pluralistic, and information intensive characteristics of successful assessments as outlined above. Towards this end, the Commission recommended the following design principles:

3.1 The complex of global environmental change information systems should support a diverse set of user communities

The requirements for information systems are driven by their potential users. The Commission identified four broad categories of users that should be supported by information systems for global environmental change policy analysis and decision-making:

- *large-scale governmental assessments* performed by international governmental organizations and individual national governments;
- *small-scale governmental assessments* performed at regional, state, and local levels;
- *independent professional assessments* performed by academic researchers, industry, consultants, and public interest groups; and
- *grass-root assessments* performed by concerned citizens, free-lance journalists, students, and other individuals outside a formal organizational setting.

Information system development strategies that support any one type of assessment at the exclusion of others will not meet the requirements of a participatory, collaborative, and pluralistic assessment enterprise. Large-scale governmental assessments can occasionally marshal the resources necessary to overcome inadequacies in the supporting information system, but smaller-scale efforts do not have this luxury. However, it is precisely these smaller-scale efforts that are the foundation for major national and international assessments. They also take the necessarily general results of large-scale assessments and apply them to more specific and often more actionable contexts.

Clearly, it would be an impossible task to construct a single information system that would adequately meet the highly diverse needs of the user communities listed above. Rather, *the strategy should be to promote the development of multiple, autonomous, but interdependent information systems that enable more effective assessments of global environmental change.* This complex of information systems will necessarily have public, commercial, and non-profit elements.

3.2 Change should be a fundamental premise

The complex of information systems constructed to support scientific research and policy analysis of global environmental change must adopt incremental and evolutionary design approaches. Just as assessments need to be iterative over relatively short time periods, so too must the development of the information systems designed to support them. The requirements of the system will change dramatically with each change in the framing of the policy debate. Furthermore, the technology and economics of information systems will continue at an extraordinary pace. Long and arduous procurement cycles and centralized architectures such as those initially specified for the Earth Observing System Data and Information System (EOSDIS) work against this fundamental premise.¹² *A complex of relatively small autonomous, but interdependent systems development efforts would effectively assure that the overall enterprise continually evolves to meet new and changing requirements.* This approach is consistent with and mutually supportive with the need for a pluralistic and iterative assessment enterprise.

Ideally, the Federal procurement system should be reformed so that government information systems can quickly adapt to changes in the needs of the assessment community and the technology best suited to meet those needs. The Commission recognizes that this is a tall order. Short of a complete overhaul of the Federal procurement system, *individual agencies and programs should be encouraged to experiment with innovative management and procurement practices that promote incremental design, implementation, and evaluation of their global environmental change information systems.*¹³

3.3 Collaboration among information providers should be a fundamental premise

Information to support effective management of social responses to global environmental change will reside in multiple information systems; maintained by a variety of governmental and independent custodians; and accessible via multiple network navigation and integration systems. As a result, there will also be a high diversity in the ownership, funding, and market dependence among individual systems. Furthermore, many of these systems are primarily designed and operated for other more immediate purposes.

There have been many technical advances, cost reductions, and improvements in current or pending standards for telecommunications, computer hardware, software, and data organization, interchange and representation. These changes make it possible to envision a system in which analysts use multiple autonomous environmental change information systems located around world as though they were a single centrally located entity. To achieve this vision, this diverse community of global environmental change information providers should work together to adopt a suite of

institutional protocols and technical standards that will enable the construction of effective network navigation and integration systems. Particular attention needs to be given to the delineation of responsibilities, finances, intellectual property, system integrity, quality control, archiving, and metadata.

As a first step towards implementing these institutional protocols and technical standards, US government, foreign government, multilateral, commercial, and non-profit providers of global environmental change information should establish and actively participate in a voluntary membership association to define, implement, and deploy these important knowledge sharing protocols and standards. A near-term agenda item for this association should be to establish certification guidelines and procedures for archival quality Internet resources. Individual information providers would have two incentives to join such an organization. First, these efforts will enlarge the potential user base for each participating provider's information products and services. Second, it will provide a richer set of information resources from which their in-house staff can draw for particular analyses. Efforts such as the CIESIN Information Cooperative have made substantial progress in this direction .

3.4 Individual information systems should leverage their efforts through existing and emerging information brokers

Libraries have a large installed base of users. Most people learn how to use a library while in high school. As a result, libraries are generally the system of first resort for anyone who wishes to explore an environmental policy issue beyond its coverage in the popular press. Unfortunately, major global environmental change information systems such as EOSDIS, are often not designed to be accessible or serviceable in library settings.

Major systems development efforts such as EOSDIS should develop explicit plans for providing broad public access via the Federal Depository Library Program. One near-term approach would be to install the necessary network connectivity, workstations, software and trained reference librarians in selected depository libraries. A more comprehensive approach would actually delegate major aspects of the global environmental change data management, archival maintenance, and public service provision to the Federal Depository Libraries. These types of approaches ensure broad geographic coverage and effectively leverages the nation's existing investment in the National Information Infrastructure (NII), the National Depository Library Program, and the individual information systems. This would be an effective pilot project to test the NII as an interactive common-carrier distribution vehicle for the public libraries in general because it focuses on a specific set of libraries, a specific information domain (the environment), and a specific audience. This type of interactive NII application would also provide an important contrast to competing applications predicated upon a broadcast model with 500 channels of television programming.

In addition to libraries, on-line information services such as America On-Line and ECONET also have large installed subscriber bases. Similarly, general purpose network navigation and browsing tools such as the World Wide Web, Gopher, and the Wide Area Information System (WAIS) have large installed bases and have rapidly become the largest volume applications of the Internet.

Recent efforts to make major national and international databases accessible such as EOSDIS accessible via the World Wide Web should be applauded.¹⁴ However, many of these efforts are tentative and are essentially diversions from a main-stream development effort targeted to a relatively small number of well-equipped high-end users.

Major sources of environmental information such as EOSDIS should be viewed as wholesalers whose products are delivered to policy-oriented end-users through these existing and emerging information brokers. Individual providers of information about global environmental change information should not attempt to create their own end-user distribution channels. Rather, they should leverage their efforts by making use of these existing and emerging capabilities. Efforts that attempt to invent their own channels often end up creating yet one more system among the cacophony of systems. Few people learn to use the new channel effectively and it will not garner the resources required to deploy it to a sufficiently broad community.

The Federal government should also establish a set of policies that encourage commercial and non-profit redistribution of environmental change information resources. Past efforts to establish preferred resellers have not been successful. Rather, the Committee on Environment and Natural Resources and the Office of Management and Budget should consider convening a forum of government, commercial and non-profit on-line environmental information services to begin the process of establishing open and equitable policies regarding redistribution of government produced environmental change information resources. These policies should be constructed to encourage competition among value-added service providers and should not be seen as a substitute for providing direct public access to the primary resource.

3.5 Access mechanisms analogous to those refined over the years for scientific and technical literature should be developed for new forms of environmental change information resources

Over the years, the scientific and technical information community has developed a number of useful mechanisms for providing access to scientific and technical literature, such as union catalogs, abstract services, citation indices, full text search and retrieval, inter-library loans, repositories, and information analysis centers. These traditional approaches are being augmented with new approaches such as electronic journals, automated table of contents services, selective dissemination of information programs, and enhanced software systems that dynamically index and rank the relevance of large bodies of textual information according to user specifications. Efforts to study and develop responses to global environmental change have created the need for access to additional types of resources such as databases, computer models and analysis software, specialized facilities (e.g., supercomputers and instrumentation), communications networks, and individual and organizational expertise. Access mechanisms for these new resource types should not be developed in isolation from those that exist for scientific literature. Rather, the capabilities should be integrated. For example, an analyst using an on-line library catalog to perform a literature search should be able learn about the existence of relevant electronic information resources through the same system. Organizations such as the Energy Information Administration and the Inter-university Consortium for Political and Social Research have greatly increased the visibility of their off-line holdings by preparing and distributing catalog records for use in library

public access catalog systems. Furthermore, libraries at major research universities are beginning to catalog specific on-line resources (see Figure 4).

Data catalog and access systems specific to global environmental change such as EOSDIS, the Global Change Master Directory and the CIESIN Data and Information Access System should be fully integrated with on-line library information systems (also called public access catalog systems). Whereas the above example provides a record for EOSDIS as a whole, it would be much more valuable for library catalogs to contain item level descriptions of the data available via the system. One near-term approach would be to produce MACHine-Readable Cataloging (MARC) compatible versions of these directories and make them accessible through the On-line Computer Library Center (OCLC) and the Research Libraries Information Network (RLIN). Libraries should also continue work in the other direction to link their public access catalog systems to archive quality Internet resources.

A fraction of the overall environmental change information management budget should be devoted to researching and prototyping mechanisms to integrate the access mechanisms for scientific literature with those for its supporting data and information. Efforts such as NASA's research competition for information system technology applicable to EOSDIS and the joint NSF, ARPA, and NASA competition for digital libraries research should be continued and expanded.

3.6 The information system should establish an effective system of incentives and penalties to ensure that information is contributed to the system in usable form

Everyone is both a user and provider of information.¹⁵ Therefore, the system should be "self-enriching." Users who have performed analyses of environmental change should have a well-defined path for contributing that information to the system. In many cases, the data and information upon which their analyses are based will be useful to others who wish to confirm or use the results, or dispute the conclusions. This type of transparency is often required before the results of new analysis will be accepted by either the broader scientific or policy communities. Transparency is a particularly important attribute of assessments that are designed from the outset to inform public policy. The common feature of programs that are successful in achieving high degrees of transparency is that all participants know the rules, procedures, time-lines and applicable standards for sharing data and information amongst themselves prior to publication, and for contributing their collective work to a recognized archive shortly after publication. Efforts such as NASA's Coordinated Data Analysis Workshops have participants agree to an explicit set of rules that delineate the data sharing responsibilities of each participant and the group as a whole.¹⁶ Other efforts, such as the Joint Global Ocean Flux Study (JGOFS) have learned that an effective policy is to make future funding contingent upon successful delivery of original data to a recognized archive. This type of penalty must be accompanied by the incentive of sufficient funding to properly prepare original data collections for archival.

The Federal government and the global environmental change assessment community should take steps to establish a voluntary membership association that would establish an acceptable set of guidelines, procedures, time-lines and applicable standards for sharing data and information produced by both publicly and privately funded global environmental change

assessment efforts. This association could also serve as a focal point to track and periodically review on-going assessment efforts, media referral, and public outreach. One approach would be to establish a special interest group with reciprocal membership and participation from relevant professional societies and non-governmental organizations such as the Society for Risk Analysis, the American Geophysical Union, the Ecological Society of America, the Environment and Energy Study Conference, the National Governors Association, the Council of State Legislators, the Natural Resources Defense Council, the Climate Change Coalition, the National Science Teachers Association, and the American Library Association.

3.7 Government produced information should be provided to all classes of users according to a single-tier pricing strategy

The current policy of the US Global Change Research Program states that, “Data should be provided at the lowest possible cost to global change researchers in the interest of full and open access to data. This cost should, as a first principle, be no more than the marginal cost of filling a specific user request. Agencies should act to streamline data sharing arrangements among researchers.”¹⁷ This policy has generally been interpreted to mean that non-researchers (i.e., commercial users) can and will be charged higher fees for access to the same data. First, this interpretation puts into motion a bureaucracy whose purpose is to determine the motive of a potential data user. How does one tell if someone is a “researcher” or not? The need to prove one’s motives to this bureaucracy in itself becomes a barrier to access. Second, effective assessments of global environmental change require collaboration across a broad spectrum of stakeholders, including commercial interests who pay taxes. Discriminatory pricing will serve to discourage this collaboration, and therefore reduce the effectiveness of the assessment enterprise. If subsidies are required to support research or other desirable public goods, their cost should be made explicit in the form of vouchers.

4. SUMMARY

This report recommends a multiple and pluralistic structure for assessments of global environmental change that is coupled with a strong information management program. No single assessment, or assessment methodology, will produce an answer that will convince policymakers that action, or inaction, is required with respect to natural or anthropogenic changes in the global environment. Rather, policymakers will look at the results of many assessments that use different methodologies, and are performed by competing stakeholders. Global environmental change information systems and policies must be structured to support these attributes of the policy process. This can be achieved by, anticipating change, supporting a broad base of user communities, establishing a collaborative network of interdependent information providers, establishing effective guidelines for contributing the data and information compiled during individual assessments to the broader community, encouraging commercial and non-profit redistribution of available data and information, and integrating access mechanisms for scientific literature and its supporting data and information.

ENDNOTES

¹ The Commission drew on the support of a project staff directed by Tom Parris of CIESIN, who is also the principle author of this document. Elizabeth DeSombre, Maryam Golnaraghi, Holly Kaufman, Rajiv Kaul, Lisa Martin, Ted Parson, Susanne Sallin, and Paul Steinberg prepared an excellent set of review papers and case studies that are available as a second volume to this report. Nancy Dickson provided frequent advice and access to the excellent gray literature archive of the Project on the Social Learning in the Management of Global Environmental Risks.

²Statement of The Honorable John H. Gibbons, Director, Office of Science and Technology Policy, before the Committee on Energy and Natural Resources, United States Senate, March 30, 1993.

³Carnegie Commission on Science, Technology, and Government, *Environmental Research and Development: Strengthening the Federal Infrastructure*, December 1992, pp. 59.

⁴Federal Coordinating Council for Science, Engineering and Technology. Committee on Earth and Environmental Sciences. *Our Changing Planet: The FY 1994 U.S. Global Change Research Program*. 1993. pp. 12-13.

⁵ The Commission reviewed the histories of the Consultative Group on International Agricultural Research, the Health Effects Institute, the Energy Modeling Forum, the Climatic Impacts Assessment Program, the National Acid Precipitation Assessment Program, the International Ozone Trends Panel, emerging strategies in the enforcement of environmental regulations and related enforcement professions, regional air quality management programs, efforts to evaluate international environmental treaties, and efforts to manage responses to the El Niño - Southern Oscillation.

⁶Hart, David. "Strategies of research policy advocacy: anthropogenic climatic change research, 1957-1974." *CSIA Discussion Paper*. Center for Science and International Affairs, John F. Kennedy School of Government, Harvard University. Cambridge, MA. 1992.

⁷ The executive summaries of the Climatic Impacts Assessment Program (CIAP) and the National Acid Precipitation Assessment Program are classic examples of this phenomenon.

⁸Lee, Kai. *Compass and Gyroscope: Integrating Science and Politics for the Environment*. Island Press. 1993. pp. 111-114.

⁹Hernon, Peter. "Discussion Forum: National Information Policy." *Government Information Quarterly*. Vol. 6, No. 3, pp. 232.

¹⁰See for example, National Research Council. Committee on Global Change. *Toward an Understanding of Global Change: Initial Priorities for U.S. Contributions to the International Geosphere-Biosphere Program*. National Academy Press. Washington, DC. 1988.

¹¹Sparrow, Malcolm K. *Imposing Duties: Government's Changing Approach to Compliance*. Praeger. 1994. pp. 101

¹² However, the managers of EOSDIS should be commended for recognizing this problem and their recent efforts to establish a more evolutionary, scalable and logically distributed design and implementation.

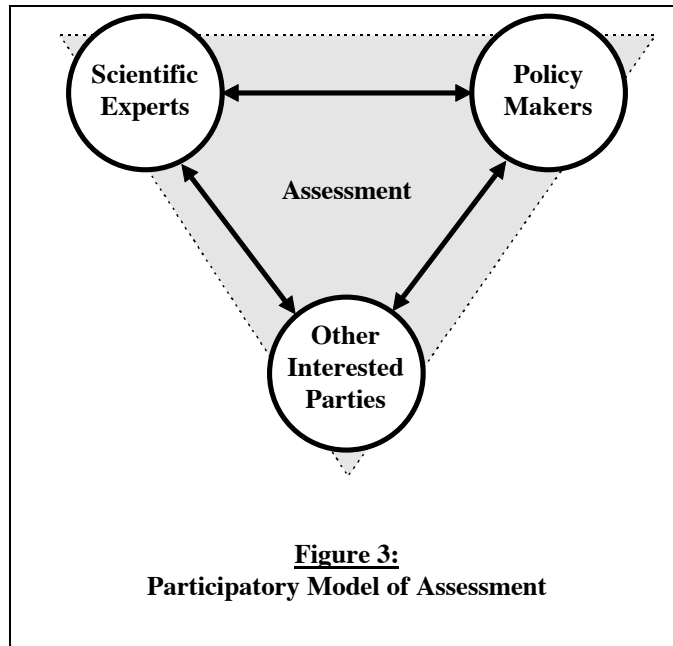
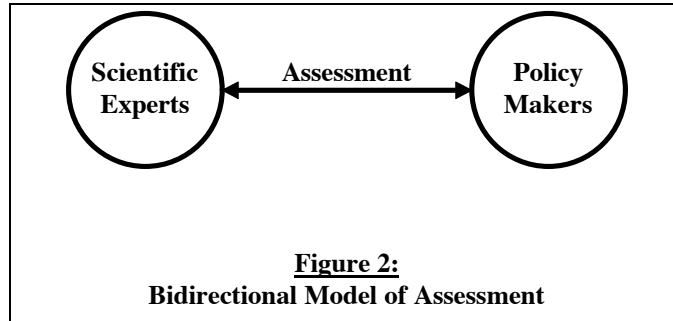
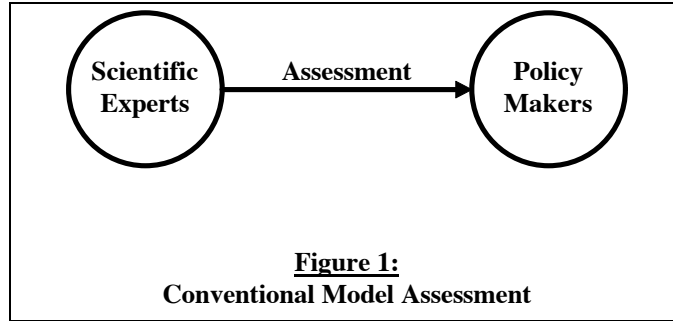
¹³see for example Horowitz, Barry M., "Some Important Implications of Open Systems Standards for Government Information Systems Development." MITRE MP 94B000057. March, 1994. Presented at the Electronic Industries Association 23rd Technology and Budget Conference, March 23, 1994. NASA's recent Cooperative Agreement Notices for Earth Science Information Partnerships appear to be a step in this direction.

¹⁴See http://harp.gsfc.nasa.gov:1729/eosdis_documents/eosdis_home.html

¹⁵Report of the United Nations Conference on Environment and Development. *Agenda 21, Chapter 40*. “Information for Decision-Making”

¹⁶These rules are reprinted in Appendix C of National Research Council, Computer Science and Telecommunications Board. *National Collaboratories: Applying Information Technology for Scientific Research*. National Academy Press. Washington, DC. 1993.

¹⁷Office of Science and Technology Policy, “Data Management for Global Change Research Policy Statements,” July, 1991.



HU LONG DISPLAY Item 1 of 1 retrieved by your search:
FIND TI EOSDIS

-----HU HOLLIS# BDE7085 /dat

AUTHOR: Earth Observing System (Program)

TITLE: Earth Observation System Data Information System [computer file]
: NASA's Mission to Planet Earth.

EDITION: V0

PUB. INFO: [Washington, D.C.? : National Aeronautics and Space
Administration, 1994?-

SUMMARY: Part of the Global Change Research Program, EOSDIS is designed
as a distributed system to support archival and distribution
of data at multiple data centers. These centers are connected
by an information management system which provides an
interface for "one stop shopping" for earth science data
allowing users to search for and order data from multiple data
centers in a single session.

TECHNICAL INFO: Mode of access: Internet. Address:

http://harp.gsfc.nasa.gov:1729/eosdis_documents/eosdis_home.html.

NOTES: Title at head of home page: EOSDIS V0 IMS Home page
Title from graphic at top of home page.

SUBJECTS: *S1 Earth Observing System (Program)--Databases.

*S2 Astronautics in earth sciences--Databases.

*S3 Earth sciences--Remote sensing--Databases.

*S4 Remote sensing--Imaging systems--Databases.

*S5 Imaging systems in earth sciences--Databases.

*S6 Earth resources technology satellites--Databases.

AUTHORS: *A1 Earth Observing System (Program)

*A2 United States. National Aeronautics and Space
Administration.

OTHER TITLES: EOSDIS V0 IMS Home page

NASA's Mission to Planet Earth

OTHER KEYWORDS: Computer network resources.

LOCATION: Networked Resource:

To access: URL is

http://harp.gsfc.nasa.gov:1729/eosdis_documents/eosdis_home.html

Based on file as of 31 August 1995.

Figure 4:
Harvard On-Line Library Information System (HOLLIS)
Bibliographic Record for EOSDIS

APPENDIX

Commission on Global Environmental Change Information Policy

Charles Zraket, Chair: Former President MITRE Corporation; Chair of the National Research Council's review of the Earth Observing System Data and Information System.

William Clark, Principle Investigator: Professor of International Science, Public Policy, and Human Development; John F. Kennedy School of Government.

John Armstrong: No affiliation.

Rosina Bierbaum: Office of Science and Technology Policy, Executive Office of the President

John Bossler: Director, Department of Geodetic Science and Surveying, School of Mathematical and Physical Sciences, Ohio State University.

Edith Brown-Weiss: Professor, School of Law, Georgetown University

Garry Brewer: Professor of Resource and Public Policy, University of Michigan.

Radford Byerly, Jr.: No affiliation.

Michael Fischer: Executive Officer, California State Coastal Conservancy.

Robert Frosch: Senior Fellow, Center for Science and International Affairs, Harvard University.

Barry Horowitz: President, MITRE Corporation.

Henry Jacoby: Co-Chair, Joint Program on the Science and Policy of Global Change; Professor of Management, Sloan School of Management, Massachusetts Institute of Technology.

Kai Lee: Director, Center for Environmental Studies, Professor of Environmental Studies, Williams College.

Barbara Liskov: Professor of Software Science and Engineering, Massachusetts Institute of Technology.

Jay Lucker: Director of Libraries, Massachusetts Institute of Technology.

Gordon MacDonald: Research Director of Environmental Studies, Institute on Global Conflict and Cooperation; Professor at the Graduate School of International Relations and Pacific Studies, University of California, San Diego.

James J. McCarthy: Director, Museum of Comparative Zoology; Professor of Biological Oceanography, Harvard University

Michael McElroy: Chair, Department of Earth and Planetary Sciences; Professor of Atmospheric Sciences, Harvard University.

M. Granger Morgan: Head, Department of Engineering and Public Policy; Professor of Engineering and Public Policy, Carnegie-Mellon University.

Eugene Skolnikoff: Professor of Political Science, Center for International Studies, Massachusetts Institute of Technology.

William Wulf: Professor of Computer Science, University of Virginia.

