Improving Integrated Assessments for Applications to Decision Making

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1. INTRODUCTION

Most integrated assessments conducted on complex environmental issues, such as climate change, failed to fully meet the needs of the decision makers they are intended to serve. This observation has been recognized by many practitioners over the last two decades (1) and also has been documented by social learning research (2).

When researchers apply assessment models as mechanistic predictive tools, they risk producing results that are not sufficiently relevant and prone to misuse in decision making. Policy-relevant assessment is more of an organic process involving researchers and the issue's stakeholders in an interactive exercise that builds understanding rather than defines "truth." Some valuable general lessons can be drawn from examining past experience in environmental assessments. Based on these lessons, improved solutions can be defined to address better the challenges common to similar endeavors.

This paper generically examines some of the shortcomings of past assessment efforts, identifies possible solutions, and provides examples of recent work on climate change and air quality planning where new approaches have been applied successfully. The emphasis is on providing *practical information* in an easily usable form for those involved in environmental assessments for decision makers.*

2. PROBLEM DEFINITION

The underlying difficulty in conducting scientific assessments to assist decision making is rooted in the divergent purposes and different professional cultures of researchers and managers (3). Scientists ultimately seek to understand an issue but the decision makers' job is to decide. Decisions usually have deadlines and must be based on whatever level of scientific understanding exists, taking account of all the other societal factors that apply to the decision. Indeed, the technical aspects are usually given less weight in the decision process than social and political factors, much to the dismay of researchers pursuing the "truth" about a problem as the scientists define it (4).

Given these deep-seated causes of misunderstanding between the producers of assessments (researchers) and the intended users of the information (decision makers) certain recurring problems are evident in most assessment efforts (3).

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* Decision making is used broadly and includes policy, management and regulation as specific types. However, because I am focusing on generalities that can apply to all these forms of decision making, these terms are used here as synonymous to avoid monotony.

There are three general shortcomings for many past environmental assessments,

1. Lack of focus on decision makers' specific information needs
2. Inadequate stakeholder involvement and communication at all phases
3. Insufficient integration of quantitative and qualitative factors relevant to the decision makers

2.1 Technical Soundness and Policy Credibility

These problems can be particularly debilitating because assessments not only must be *technically sound* but also *policy credible* to be most useful to decision makers. Researchers are well versed on what is required to ensure scientific credibility, such as using well-documented and peer-reviewed information. But they often find the needs of decision makers require stretching assumptions beyond what they believe "good science" allows, forcing them to make expert judgements and informed guesses or else forfeit contributing effectively to the process. The other crucial assessment attribute, policy credibility, is less well understood by researchers. The assessment's credibility depends on how transparent, inclusive and unbiased the whole process is perceived to be by stakeholders, as much as the credibility of justice depends on the legal process followed. The scientific and decision making participants in the overall assessment process need a greater mutual understanding of each others' arenas because inevitably they must interact in the conduct of policy-relevant assessments. In the past, the interaction typically has been ad hoc, sporadic and often an afterthought rather than a carefully planned process.

Many of the weaknesses of policy-relevant assessments are exacerbated by the lack of adequate dialogue between the producers and users of the assessment, not only before but also during and after it is conducted. There has been a tendency to "ready-fire-aim" rather than systematically ensuring a more productive sequence of: a) ready -- with dialogue; b) aim -- with stakeholder involvement in the design; and c) fire -- with continued dialogue and involvement throughout the implementation and evaluation.

The flawed sequence often results from researchers first discovering environmental issues and formulating them in their terms, before the issue becomes an active policy problem when the decision makers reframe it for their own context. Assessments are often designed based on the researchers' understanding of the scientific issues and their educated guesses of what decision makers would like to know rather than eliciting the decision makers' needs at the onset.

With an approach, that fails to fully engage the assessment's target audience in the initial design, it is unlikely that even the assessment's questions will be focused on those matters most relevant to the decision making. What usually results is a state-of-the-science assessment with minimal usefulness to decision making. In practice such results unintentionally provide fodder for opposing advocates on the issue to use selectively for supporting their predetermined positions in the policy debate.

By applying multi-stakeholder approaches, assessment processes not only focus on the science but also inform the decision makers in a manner that facilitates sustainable outcomes that are technically and politically viable for society. Some of the key factors for integrated assessments as well as the associated benefits and challenges are outlined in table 1.

Table 1
Integrated Assessments: Examples of General Factors, Benefits and Challenges

General Factors in Designing and Conducting Assessments

- Target audience
- Technical methods
- Communication strategy
- Outputs and deliverables
- Bounds: spatial, temporal and issue
- Management approach
- Review and evaluation
- Quality assurance and control

Potential Benefits of Assessment Process

- Identification of key technical and decision making issues
- Development of a problem analysis framework to structure the issue
- Integration of information from multiple disciplines and sources
- Explicit definition of major assumptions and uncertainties
- Establishment of priorities for future policy-relevant research
- Development of broader understanding among stakeholders
- Creation of a basis for more informed decision making

Common Challenges for Assessments

Technical issues

- Poorly understood natural processes
- Extrapolating in space and time
- Data and observation limitations
- Quantifying cumulative uncertainties

Social issues

- Articulating processes
- Politicizing science
- Defining the roles of producers versus users
- Diverse use of language and varied expectations
- Difference between scientific and decision making criteria
- Identifying and recruiting constructive participation of issue stakeholders

3. LESSONS AND SOLUTIONS

Based on the experiences of dozens of environmental assessments on a range of issues in several countries, some significant lessons emerge from past efforts that provide insights for improving the usefulness of assessments for decision makers. The Social Learning Project of Clark and his colleagues at Harvard University is documenting how decision makers have responded to various assessments (2). Five general lessons about assessments that have been judged most effective *by decision makers* (5) are as follows.

The assessment process was inclusive and well designed. Communication can be more important than model integration in determining success. Complex model wiring diagrams suggesting all the pathways to be studied are of limited value unless there is a carefully planned process of interactive flow of information among researchers, synthesizers, stakeholders, reviewers and end users.

The assessment results in expanding options for decision makers. The assessment process can provide a vehicle for finding win-win solutions. Merely providing detailed analysis of specific policies rarely advances the decisions as usefully as when new options are generated in an interactive process between producers and users of the information.

The assessment focuses on real uses at the regional level. Broad generalizations on the national or global scale have limited value at the more local scales where most impacts of a decision are experienced. Averages integrating over large areas can obscure the more localized texture that political representation is based on in national and global fora.

Multiple partial assessments are performed on key components. The end results of large integrations of many factors tend to suffer from the limitations of their weakest links. These limitations and their complexity make them harder to use and interpret by decision makers than sets of comparable, separate analyses.

Assessments are conducted repeatedly by a core group. Single-time grand integration efforts are less likely to benefit from the learning required to be most useful for decision makers. Assessments ultimately need iteration to yield successively better results with a stable core group of assessors who incorporate the learning as they proceed.

These overall lessons indicate the primary importance of the *process* not just the report or other tangible outputs of an assessment effort. In fact, the reports may often be the least valuable output when one examines assessments as representing interactive learning processes involving researchers, assessors, decision makers, stakeholders and the public.

3.1 Defining Policy-Relevant Assessments

One of the difficulties in discussing assessments is that the concept is used in a variety of ways and has no widely accepted definition. While assessments generally apply to some type of focused analysis of a topic, the word is used to mean everything from an informed opinion to complex models to risk analyses. I offer a broad definition here, not as the sole way assessment can be defined, but rather as an explicit definition that covers the kind of

policy-relevant and science-based endeavors we are examining.

Policy-relevant assessment can be defined as:

> *An iterative multi-stakeholder process for systematically analyzing data and synthesizing information into a form that facilitates use in decision making.*

These assessments are both a scientific exercise and a social process. While they link the science to the needs of decision makers, they do not usurp the role of the applicable decision making process they support. Such assessments are a form of decision support tool that can be applied along with other tools and factors in the development of actions and plans.

3.2 Attributes of Successful Assessments

Based on the lessons of past efforts there are a number of factors that enhance the effectiveness of policy-relevant assessments.

- Responding to clearly defined needs relevant to decision making
- Involving decision makers in framing the questions and designing the process
- Maintaining interaction with end users during planning and implementation
- Developing and implementing a multi-stakeholder communication strategy
- Establishing credibility with periodic open reviews of the science by research peers and the assessment's process and assumptions by stakeholders
- Using the full spectrum of research approaches and tools to address the issues of importance to decision makers that can be quantitatively modeled and those that only can be qualitatively described, explicitly estimating uncertainties
- Managing the process for successful assessment outputs rather than as research
- Using assessment specialists to integrate the outputs of expert teams

None of these elements alone is sufficient to ensure success. For effectiveness they should be applied as a carefully designed ensemble adapted for the requirements of a specific assessment issue. These are illustrated in Sections 4 to 6 of this paper by their application in recent integrated assessment efforts for climate change and air quality, two issues of widespread and active endeavor where the author has extensive experience.

3.3 Process-Guided Assessment Paradigm

When taken together these attributes suggest a new model for conducting assessments that is less mechanistic and more organic than previous efforts. Assessment can be practiced as a learning-centered dialogue rather than the traditional exercise in defining "truth" or predicting probable future outcomes. The science can and should define what is known and the level of uncertainty, but it is useful to remain humbled by the reality that research is more efficient at converting ignorance into new uncertainties, than it is at turning uncertainties into "facts" (6). Table 2 outlines new emphases for policy-relevant assessments.

Table 2
New Emphases for Policy-Relevant Assessments

Previous Style	Evolving Style
Mechanistic models	Organic models
Reductionist	Holistic
Science focus	Decision context focus
Seeks truth	Provides learning
Generating predictions	Generating options
Defining outcomes	Establishing processes
Producing answers	Framing questions

When science interacts with decision making a new trans-scientific activity results (7), different from unfettered discovery and embedded in the human value judgements that dominate decision making. Because of the challenges this presents, especially to the hyper-rationalistic nature of modern science, a systematic dialogue among the producers and users of an assessment is a crucial element that is often overlooked. Such a dialogue implies communications in both directions aimed at understanding the different perspectives of research and decision making (3).

Ideally before an assessment is even designed, a structured dialogue process should be implemented. With this ongoing dialogue as a foundation, a design can begin with the involvement of not only the assessors and their clients but also the full range of stakeholders who will be impacted by the issue. The assessment process should be designed to ensure the appropriate participation by researcher, assessors, decision makers, stakeholders and the public. Figure 1 illustrates the assessment cycle involving the producers and users of policy-relevant technical information.

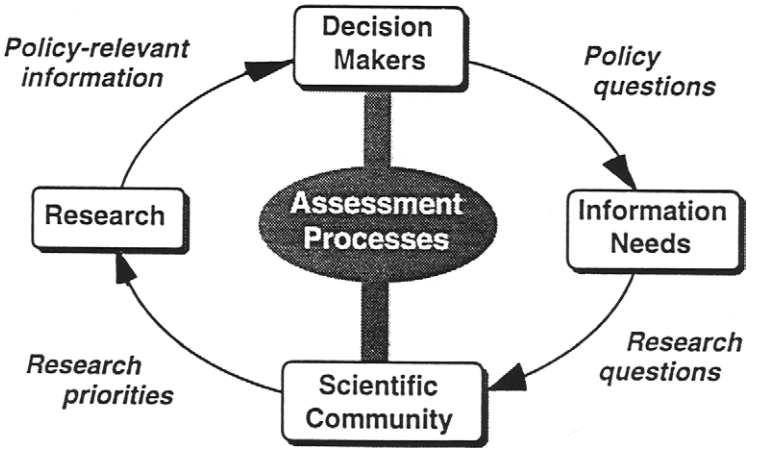

Figure 1. Assessment as an iterative process linking science and decision making.

Process-guided assessments require three phases to achieve the interactive learning effort of the evolving new paradigm,

Phase 1 - Facilitated Dialogue. An ongoing, planned effort that is structured for maximum interaction among participants initially to identify users' needs, determine scientific capabilities, elucidate stakeholders concerns and build mutual understanding for the assessment.

Phase 2 - Interactive Design. An interactive approach is used to clarify goals, define roles, identify the constituency for the assessment and initiate outreach activities. This includes reviewing the proposed roles, methods and outputs to ensure credibility.

Phase 3 - Multi-stakeholder Implementation. The final phase involves conducting the formal assessment, reviewing interim and final results, explaining the significance to users, and maintaining internal and external communications based on a well-defined plan followed by evaluation and then iteration.

In the remaining sections of this paper, examples of actual projects that have been conducted are provided to explain the challenges and benefits of some improved approaches to policy-relevant environmental assessments.

4. IMPORTANCE OF DIALOGUE

A productive dialogue among diverse researchers, decision makers and impacted stakeholders should be structured to facilitate effective communication. Often those seeking to promote dialogue merely get amorphous communication because they fail to develop a viable process for focused interaction. A similar problem would be familiar to researchers if an amateur collected data but neither with a plan for how and where it was to be collected nor adequate documentation to make the findings usable to science.

Dialogues are greatly improved when professional experts in group processes and facilitation are involved. A rich set of theory, information, approaches and experience exists on the subjects of conducting decision making, enhancing dialogue, applying knowledge theory and using elicitation techniques such as focus groups (8).

When a dialogue is well designed and executed it can be the source of useful learning for all the participants in assessments. Participants can learn the context in which they each view the issue, define the range of assumptions they hold and develop the questions of greatest value to the decision making. The involvement of the users and producers of the assessment in this process provides the basis for more informed assessment questions and better planning of the impending analyses. This approach lays the ground work for the ongoing interactive dialogue that can continue throughout the phases and iterations of the assessment and decision-making processes.

4.1 National Climate Change Dialogue

An example from the area of climate change illustrate this process. The "Joint Climate Project to Address Decision Makers' Uncertainties" was begun in the United States in 1989 as a government-industry collaboration with sponsorship by seven federal agencies and the electric power utilities (9). The purpose of the dialogue was to gain a better understanding of what the information needs of future decision makers might be so that more relevant climate change research and assessments could be conducted. The multi-stakeholder dialogue involving researchers and decision makers revealed that most of the $1.6 billion spent annually on climate research was focused on only one of the three areas crucial to decision makers. More than 90% of the planned work was on earth system predictions with practically nothing on climate impacts or response options -- two areas that were of greatest importance to decision making.

The project's interviews and workshops indicated a wide gulf between what researchers considered important to study and what decision makers wanted to know. The most valuable conclusion of the dialogue was the pressing need for more effective means of communication between the science and decision-making communities. The learning the participants gained from their involvement in the dialogue is a major benefit of such a process because it sets the stage for more effective assessment as well as decision making by providing understanding among the actors that otherwise would not have occurred.

4.2 International Dialogue on Climate

During the early 1990's the Dutch National Research Programme on Global Air Pollution and Climate Change initiated a national multi-stakeholder dialogue on climate change as part of their assessment program (10). The multi-stakeholder dialogues underway in both the United States and the Netherlands recognized the fundamentally international aspects to decision making on global climate change. As a result, the Dutch Climate Programme and the U.S. EPA co-funded a pilot international dialogue examining decision makers' information needs over the next decade on the climate issue (11). This cross-cultural dialogue was intended to complement the pioneering efforts under the United Nations to develop an international climate treaty with input from a scientific body it convened, the Intergovernmental Panel on Climate Change (IPCC).

The bilaterally sponsored dialogue project entitled, "Enhancing the Effectiveness of Research to Assist International Climate Change Policy Development" began in 1994 and involved decision makers and researchers from six key nations: China, India, Brazil, Poland, United States, and Netherlands. A structured and professionally facilitated dialogue was conducted to enhance understanding and build a stronger foundation for future assessments, policy-relevant research and decision making.

The project began with a series of individual interviews with decision makers from governments, industries and non-governmental organizations in each of the six nations. From these off-the-record meetings the project team developed an analysis of the range of perspectives on the climate issue in each nation. These interview-based synopses of the *issue landscape* in each nation were shared with a workshop of about 40 decision makers representing key sectors from all six nations. Details of the underlying theory, methods and results are presented in the project report (11).

After reviewing the different national perspectives as seen by diverse stakeholders, the decision makers at the workshop defined a *range of possible policy paths* about which research could provide information on to assist future decision making. A group facilitation process we dubbed the "three P's" was applied by successively defining *probable* (status quo), *preferable* (idealized) and *possible* (achievable) future scenarios for policy. The decision makers developed a series of three P's futures using the approach shown in Figure 2. There was no attempt to agree on one consensus outcome; instead the minimum number of policy paths that reflected all points of view was sought.

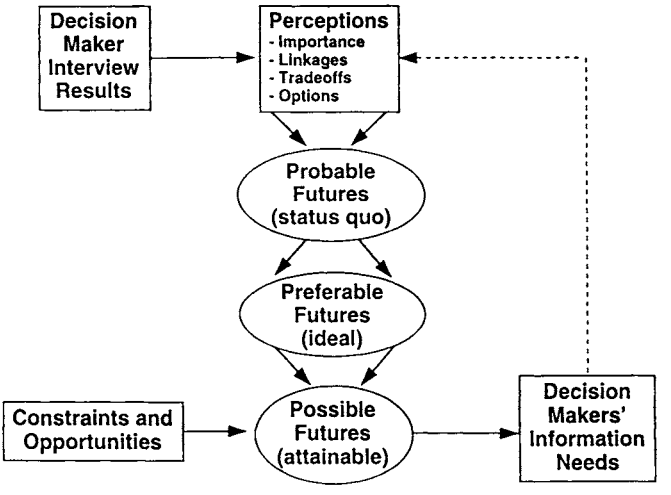

Figure 2. Example of a dialogue process for defining decision makers' information needs.

The international decision makers first established the range of possible outcomes for policy if things continue as they seem now with the *status quo*. The group of decision makers created several policy paths that covered all likely results given current conditions with descriptive titles including: too little/too late; realistic extrapolated trends; strained sustainability; sustainability moderately exceeded; sustainability significantly exceeded; and depletion and exhaustion. As the titles of the probable scenarios suggests, nobody was very hopeful about the status quo outcomes and this built enthusiasm for seeing if better options could be defined.

Then after developing the range of probable outcomes, the workshop participants divided into groups examining what ideal *preferable* future policy scenarios might be, without the constraints of current situations. From these sessions the decision makers agreed on five preferable futures encompassing every bodies aspirations including: globally stabilized emissions; industrial countries emission reductions; transition to renewable energy; high-energy sustainable; and low-energy sustainable futures.

Finally, the group took the five preferable (*most desired*) future scenarios they outlined and applied constrains to come up with the a range for possible (attainable) futures. They then identified the key information needs that research and assessment could address to help

develop, evaluate, select and implement these options. Researchers then examined the decision makers' information needs and identified what science could do in the next decade to address the needs of the future. Decision makers from the previous workshop participated in the exercise to ensure continued communication.

The outcome was a set of research objectives that is ahead of the current policy needs. To understand what other options exist within each societies' stakeholders, the dialogue went beyond the upcoming series of negotiations to identify a range of future information needs. Determining the intra-national diversity of views among stakeholders provides insight beyond the current national positions in the negotiations to identify other options that might later appear as the politics change. Even in non-democratic China, a wide range of policy views existed that could emerge in the future. The project's future-looking approach helps to avoid the common situation where by the time research is completed the policy questions have changed.

Table 3
Common Features of Negotiations and Dialogues on Controversial Issues

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Negotiations -- often necessary for solutions but not always sufficient because:

- many perspectives are reduced to limited number of official positions
- motivations and range of options for actors are not explicit
- each party seeks maximum advantage
- convergence is toward single least objectionable outcome

Dialogues -- can facilitate more productive negotiations by:

- expanding the range of positions addressed
- increasing understanding by examining underlying motives
- promoting consensus on a range of acceptable options
- establishing a possible basis for win-win solutions

This overview of the climate dialogues is presented to give some examples of how facilitated processes can yield valuable insights not possible with the business-as-usual approaches to linking science and decision making. In all three cited dialogues, participants reported gaining understanding about other sectors that otherwise would have been impossible, which provided a stronger foundation for better assessments and improved decision making.

5. VALUE OF INTERACTIVE DESIGN

The ongoing effort by the United Kingdom to develop an integrated climate impacts assessment program provides a recent example of the effectiveness of interactive design (12). The UK Department of Environment and the Environment Agency wanted to design an

impacts assessment program in partnership with other government agencies, regional governments and the private sector. The goal was to establish a long-term program that was highly credible technically and would be accepted and co-funded by a range of stakeholders.

They used an independent third party to conduct and broker a dialogue among the potential sponsors and stakeholders. A series of interviews was conducted with UK stakeholders to determine the range of perspective, types of information needs and prospects for joining a collaborative government-private sector climate impacts assessment effort. Based on the interview results a set of common needs and divergent concerns was compiled and presented at a multi-stakeholder workshop. A dialogue ensued to determine how much support existed for the collaborative effort as well as what elements and process needed to be in place for it to work and garner broad support. Using the consensus criteria developed in the workshop, a group of leading assessment experts (mainly from the UK) formulated an approach to meet the needs of the decision makers and attract stakeholder participation.

The stakeholders desired a staged development rather than single monolithic assessment. The expert team defined three major dimensions for examining impacts over time: 1) natural systems; 2) socio-economic sectors; and, 3) geographic regions. These dimensions (Figure 3) covered 400 million possible interactions for the UK with 10 recognized types of natural systems, 10 geographical regions and 40 defined economic sectors. Obviously, the assessment would have to begin by integrating among subsets of all the possible elements in order to be manageable and technically tractable.

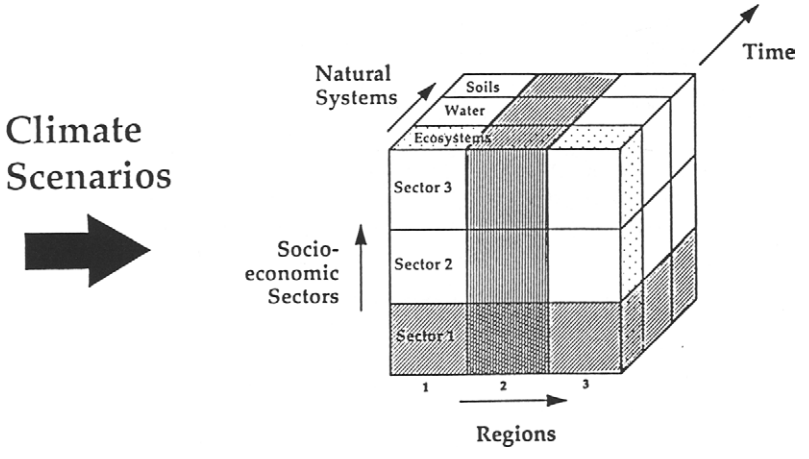

Figure 3. Dimensions of integration for climate impacts assessments

Using pilot assessments integrating across each of the three dimensions can produce useful analyses that will contribute to the overall assessment goals of informing decision makers. The initial assessment activities are proposed to use standardized climate scenarios to examine: 1) how changes in water resources will impact natural and human systems; 2) how impacts of climate on key industries at risk will effect insurance losses; and 3) how the natural and human system in the uplands region will be impacted.

The interactive design project also identified an organizational structure and processes

for a collaborative assessment program based on stakeholders input and the desire to ensure policy relevance as well as technical soundness. The design includes a core assessment staff, a government-private sector steering committee of sponsors, and both scientific and decision maker advisory bodies to review the relevancy and soundness of the program (Figure 4). The modular nature of the activities allows flexibility and use of the best expertise for each portion of the assessment as well as continuity of the core group of assessors. This multi-stakeholder program will help build consensus on impacts and response options while reducing the potential for the wasteful dueling-scientists approach that characterizes many controversial issues where cooperative assessments are lacking.

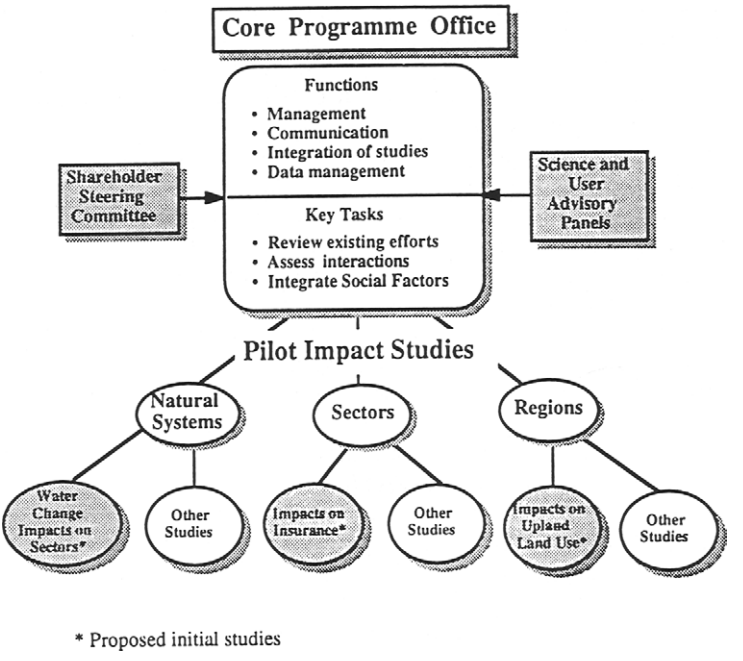

Figure 4. Proposed structure of the UK Integrated Climate Impacts Programme

6. SUCCESSFUL MULTI-STAKEHOLDER IMPLEMENTATION

The success of a policy-relevant assessment is measured best by its direct and indirect contribution to the decision making it was designed to assist. When the newspaper headlines proclaimed that the seven western U.S. states had reached consensus on an air quality plan for the next 40 years (13), it was a testament to the effectiveness of the Assessment of Alternative Emission Management Scenarios conducted for the Grand Canyon Visibility and Transport Commission (14). The integrated assessment they designed and sponsored is an example of a true multi-stakeholder process embodying all of the elements crucial for policy-relevant assessments in Section 3.2.

The Commission was established by the Clean Air Act Amendments of 1990 to involve the seven western governors in developing a strategy for protecting scenic vistas and air quality while accommodating rapid economic growth. They embarked on a six year effort that culminated in unprecedented long-term agreement on emissions planning across a diverse region with different political and economic interests.

The process began with an extended dialogue among the various states, industries, federal agencies, Indian nations, environmental groups and the public on what and how to address the challenge of maintaining and improving regional air quality while enabling economic growth. Facilitated workshops around the region involved the full range of stakeholders in framing the issues and developing mutual understanding. After more than three years of dialogue and planning, the Commission undertook a technical assessment of emissions management alternatives to inform the governors decision making.

A core group of knowledgeable stakeholders from government and the private sector worked together in committees to design the assessment with review by researchers and decision makers. The assessment was overseen by the Western Governors Association, funded by U.S. EPA and conducted by an independent contractor team of leading experts managed by Science and Policy Associates, Inc.

The resulting policy-relevant assessment was successful in large part because it addressed both the quantitative and qualitative aspects of these complex issues. For the factors where quantifiable relationships and adequate models existed, such as for emissions sources, air quality changes and the economics of control, the assessment provided model outputs to illustrate the consequences of five scenarios agreed to by decision makers. The scenarios for emissions management ranged from doing nothing more than current law to doing everything technologically feasible to reduce emissions with three variations in between.

The *primary assessment* provided decision makers with computer-based capabilities to examine the consequences of the various options, all using the same set of scenarios and analyses in order to aid decision making rather than fight over arcane technical difference. At the outset of the project key stakeholders jointly agreed to an approach, data and methods so that their focus was on decision options not debating contradictory results of competing analyses.

Whereas the primary portion of the assessment dealt with those factors that could be quantitatively modeled, the *secondary assessment* tackled the other key factors for decision makers that could not be modeled, such as: most ecological impacts, administrative ease, and equity among stakeholders. These largely qualitative factors where examined for each alternative emission scenario by using approaches such as expert judgement and surveys to avoid them being neglected when considering the quantitative outputs. This two-tiered approach avoided the black-box syndrome where model results lead to conclusions that omit key factors for decision makers simply because they are not yet adequately quantified.

The role of integration in the assessment went beyond linking modules of a model to include packaging the quantitative and qualitative aspects of the analyzes for each option in a manner that facilitated consensus building among the governors. The assessment's overall

process provided not only useful information geared to decision makers' explicit needs but a structure for the stakeholders to interact that fostered the level of understanding and cooperation necessary to reach agreement on a technically sound and policy credible outcome.

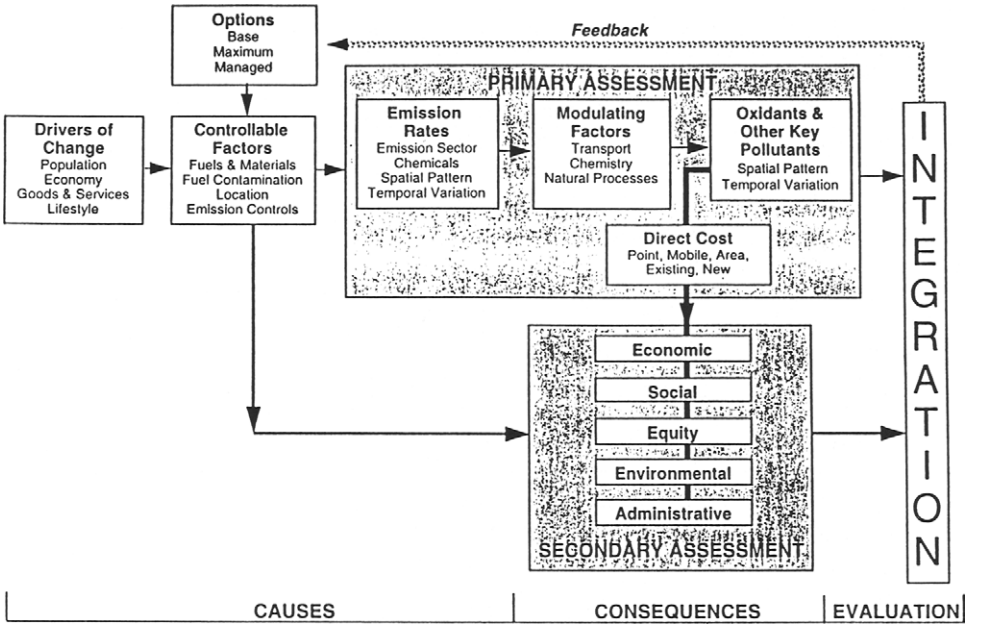

Figure 5. Western US Air Quality Assessment of Emissions Management Scenarios for the Grand Canyon Visibility and Transport Commission (14).

7. CONCLUSIONS

Improving integrated assessments to meet the needs of decision makers requires new approaches that involve stakeholders in interactive learning processes. Facilitated dialogues between the producers and users of assessments build understanding, enhance the relevancy and increase the credibility of the results.

The value of moving beyond traditional mechanistic approaches is demonstrated by recent examples of successful assessments applying structured dialogues, interactive design phases and multi-stakeholder implementation. Policy-relevant integrated assessments are *iterative learning processes* rather than truth defining end-points. To be of greatest value they must include both the quantitative and qualitative factors for analyzing the decision making options.

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