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The European Forum on Integrated Environmental Assessment

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Integrated Environmental Assessment (IEA) can be loosely defined as policy-relevant, multidisciplinary research on environmental issues. Many, diverse activities in this broad field are ongoing, but the approaches lack the structure, standardization and quality control common in disciplinary research. IEA has three stages: “structuring the problem”, “analyzing the problem” and “communicating the findings and insights”. Each stage has its inherent difficulties, not least because problem definition and analysis are neither separable nor unambiguous nor unique. Difficulties are exacerbated in the first and third stages by the necessity for science and policy to work together. Difficulties are exacerbated in the second stage by the necessity of different scientific disciplines to cooperate. The European Forum on Integrated Environmental Assessment is an initiative to improve scientific quality and policy-relevance of IEA, by organizing two series of workshops, one looking in detail at current and desired scientific practices, the other reviewing current and establishing further applications of IEA to environmental issues in Europe.

1. Introduction

Integrated environmental assessment is an active and rapidly developing field. It involves scientists and decision makers from a diversity of backgrounds and communities. Many approaches to this complicated but promising field coexist. In order to have integrated environmental assessment bear its best possible fruits, cross-fertilization of the various approaches practised in this field and community building are needed, not least to ensure critical peer review of integrated assessment activities. This article describes an initiative to serve such a goal, namely the establishment of the European Forum on Integrated Environmental Assessment (EFIEA).

The two main objectives of the EFIEA are:

(1) to improve the scientific quality of integrated environmental assessment;

(2) to strengthen the interaction between environmental science and policy making.

In addition, the EFIEA fosters cooperation between scientists and decision makers inside the European Union, communication and cooperation outside the EU, and training of IEA techniques.

Before going into the EFIEA’s planned activities in section 3, the next section briefly reviews the state-of-the-art in integrated environmental assessment, justifying the need for a more structured approach to IEA. Other reviews and assessments can be found in Bailey [6], Bailey et al. [7], Dowlatabadi [13], Henderson-Sellers [26], Hordijk and Kroeze [31], Morgan and Dowlatabadi [46], Parson [52–54], Risbey et al. [64], Rotmans [68], Rotmans and Dowlatabadi [70], Rotmans and van Asselt [69], Schneider [72], Weyant [81] and Weyant et al. [82]. Section 4 concludes by describing the possible benefits of the EFIEA.

2. State-of-the-art

2.1. Integrated assessment defined

A number of definitions of integrated assessment are around in the literature. Perhaps the broadest definition possible is the one used by the IPCC (Weyant et al. [82]):

> Assessment is integrated when it draws on a broader set of knowledge domains than are represented in the research product of a single discipline. Assessment is distinguished from disciplinary research by its purpose: To inform policy and decision making, rather than to advance knowledge for its intrinsic value.

Rotmans and Dowlatabadi [70] phrase it as follows:

> In general, integrated assessment can be defined as an interdisciplinary process of combining, interpreting and communicating knowledge from diverse scientific disciplines in such a way that the whole cause–effect chain of a problem can be evaluated from a synoptic perspective with two characteristics:
>
> (i) IAs should have added value compared to single disciplinary oriented assessment;
>
> (ii) IAs should provide useful information to decision makers.

They also offer an alternative definition:

> Integrated assessment is policy motivated research to develop an understanding of the issue, not based on disciplinary boundaries, but based on boundaries defined by the problem
>
> - to offer insights to the research community for prioritization of their efforts;
> - to offer insights to the decision-making community on the design of their policies.

Parson [52] prefers to phrase it as

> The two defining characteristics [of integrated assessment] are (a) that it seeks to provide information of use to some significant decision maker rather than merely advancing understanding for its own sake; and (b) that it brings together a broader set of areas, methods, styles of study, or degrees of certainty, than would typically characterize a study of the same issue within the bounds of a single research discipline.

In any of these definitions, "integrated" conveys a message of multi- or interdisciplinarity, and "assessment" a message of policy relevance. We use this as our guide, without competing with the above authors in eloquence. Note that we do deviate from the two Rotmans and Dowlatabadi definitions which presume that a clearly defined problem exists – one of the purposes of integrated assessment may be to define the problem. Also note that (i) the whole of integrated assessment should be greater than the sum of the disciplinary parts; (ii) the disciplines preferably participate at equal footing;[1] and (iii) problem structuring and analysis preferably operate at equal footing.

Loosely defined as being policy-relevant, multidisciplinary research into complex environmental issues, IEA is nothing new. Toth and Hisznyik [79] place IEA in its historical context.

Integrated assessment can serve various purposes and can be done in various ways. Figure 1 is a simplified schematic of the various stages of and approaches to IEA. As a first step, the problem needs to be identified, and structured. This is easier said than done. IEA is typically applied to complex issues. Spelling out, and agreeing on what is actually the problem may be major task. One of the goals of IEA may be to structure or frame the issue. In this stage, discussion between scientists, policy makers and other stakeholders is extremely important. Figure 1 displays two alternatives to stage 2, analyzing the problem. At the one extreme, IEA is a purely participatory process. This is sometimes done by multidisciplinary panels of scientists, such as, for instance, the Intergovernmental Panel on Climate Change. In other forms, the users (targeted decision makers in government and industry, or even ordinary citizens) are actively involved, for instance, in focus groups or policy exercises. At the other extreme, answers are sought with an integrated model, i.e., a system's model in one of its many possible manifestations. In practice, stage 2 is done somewhere in between the two extremes of pure discussion and pure modeling, with models (sectoral, soft-linked, hard-linked or integrated) supporting expert panels and focus groups,[2] or expert panels and focus groups supporting models.[3]

[1] The meaning of "at equal footing" is best demonstrated with an example. The *DICE* model (Nordhaus [50]) combines the simplest of economic models with the simplest of climate models. The only interesting aspect of the model is the interaction between economy and climate. Thus, the disciplines are at equal footing. In the successor of *DICE* – *RICE* (Nordhaus and Yang [51]) – the economic parts are regionalized whereas the climatological parts remain the same. Thus, the disciplines are no longer at equal footing. In another of *DICE*'s descendants, *OMEGA* by Janssen [35], the carbon cycle and climate model are replaced by a more complicated version, while the economic parts remain the same.

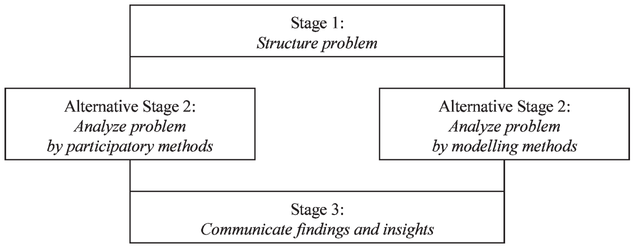

Figure 1. A schematic of the tasks of and approaches to integrated assessment.

Each way of approaching stage 2 has its advantages and disadvantages. Formalization of integrated assessment in a mathematical model has a number of advantages, such as: (i) internal consistency; (ii) subject to formal sensitivity, robustness and uncertainty analyses; and (iii) transportability.[4] Disadvantages are that: (i) only well-defined problems can be analyzed; (ii) it is hard to represent the "softer" parts of integrated assessment (e.g., social structure, politics); and (iii) continuous intuition checks (e.g., to prevent overextrapolation) are absent in a computer code.[5] Advantages and disadvantages of participatory approaches mirror those of modeling.

The difference in comparative advantages between the two approaches is to a large extent a reflection of their different goals. Participatory integrated assessment particularly aims at problem structuring (section 2.2) and communication (section 2.4); in integrated analysis, its main contribution lies in analyzing the non-modelable.

It can therefore be argued that proper integrated assessment combines a modeling approach with a discussion one, so as to have the advantages of both. This is easier said than done – indeed, in the worst case, we end up with the disadvantages of both. One purpose of the European Forum on Integrated Environmental Assessment is to lay out a route to a fruitful combination. The less structured a problem, the more prominent is the role of discussion over modeling.

In stage 3, the findings and insights are communicated to the relevant audience. This again involves extensive discussion between scientists, policy makers and stakeholders.

[2] See, for example, van der Sluis and Jaeger [74] and ULYSSES (Duerrenberger et al. [16], Jaeger et al. [34], Kasemir et al. [36,37], Ravetz [63]).

[3] See Hordijk [29] for a model review by an expert panel.

[4] Some would argue that an additional advantage of mathematical formalization is transparency. However, transparency is a relative concept. A mathematical model is only transparent to one with a fair understanding of mathematics. Complex models are only transparent to the initiated in that particular brand of modeling. In addition, qualitative assessments can also be transparent, though not necessarily to a mathematician.

[5] Some would argue that mathematical formalization does not ensure policy-relevance, a fourth disadvantage. However, policy-relevance is not precluded either. Furthermore, qualitative assessments are not necessarily more policy-relevant.

Note that in reality the three stages of figure 1 are not neatly separated or successive. Problem definitions are constantly refined and revised, partly in reaction to the results of the analysis, partly due to changing circumstances. Tentative results are continually communicated, discussed and questioned. Note also that various groups working in IEA place different emphases on the four boxes of figure 1, and sometimes argue that their preferred box is all there is to IEA. The latter should be discouraged.

A further distinction between the various integrated assessment approaches regards the differences that can be perceived in the perception of the problem (rather than in the study design). In a vertical integrated assessment, all aspects of one particular issue (e.g., climate change, acidification) are combined. In a horizontal integrated assessment, all aspects of a sector (e.g., transport), system (e.g., a river basin) or region (e.g., an island) are combined.[6] Horizontal and vertical integrated assessment serve different purposes, the second aiming at a comprehensive sectoral or regional policy, and the first aiming at a comprehensive issue policy.

In the remainder of this section, we continue to elaborate the scheme of figure 1, starting with structuring the problem, continuing with integrated analysis, and finishing with communicating the results. Integrated analysis is more commonly done using integrated (assessment) models than using participatory approaches. The literature pays more attention to integrated analysis than to problem structuring and communication combined. This situation is reflected in the length of the treatment below. However, the EFIEA will try to correct some of this imbalance. Haigh [24] and Jaeger [33] pay more attention to the interface between policy and science.

2.2. Structuring problems

In its first stage, integrated assessment is aimed at defining the problem. In many a case, the nature and boundaries of the “problem” at hand are vague and subject to discussion (cf. Hisschemoeller and Hoppe [27]). In order to analyze it, a problem needs to be clearly defined and well-structured, particularly if modeling is the prime means of analysis. For want of clarity from decision makers, analysts often define and structure a problem as they think is best, or as they can solve it. Indeed, this is recognized below as a source of differences between integrated assessment models but of course it holds for other forms of analysis as well. Participatory integrated assessment, bringing researchers, decision makers and stakeholders together, could contribute to spelling out the various views on the problem, so that analysts not only study a problem in a manner that more closely resembles decision makers’ and other stakeholders’ concerns,[7] but also study all different perceptions that decision makers and other stakeholders have of the problem.

This could imply that researchers are confronted with problems for which no or limited methodologies are available. This should spur methodological innovation, rather than shunning such problems.

2.3. Integrated analysis

As noted above, we view participatory integrated assessment and integrated assessment modeling as two complementary approaches, the one being strong where the other one is weak and *vice versa*. It is to be noted that structured thinking about and application of participatory integrated analysis to complex environmental issues such as climate change and acidification are less well-developed than integrated assessment modeling.[8]

2.3.1. Participatory integrated analysis

In the second stage of integrated assessment, participatory integrated assessment aims at integrating various sources of knowledge in a policy-relevant manner. Computer models are the best way known to date for studying problems that can be formalized in mathematical terms but not solved analytically. Some issues do not readily lend themselves to such an approach, and therefore tend to be excluded from models, or included in some *ad hoc* way. Participatory integrated assessment may help in this, for instance, in determining the value systems (relating to issues of monetization, substitutability, aggregation, compensation) to be incorporated, or to include decision making in an interactive manner. There are many established techniques for involving broader stakeholders in a decision framework.[9] However, there is perhaps less experience in their application to larger scale policy debates, for instance, at the European level. The ULYSSES project is developing these techniques, particularly in the context of model applications (Duerrenberger et al. [16], Jaeger et al. [34], Kasemir et al. [36,37], Ravetz [63]).

Experts are often associated with a certain power in decision making not commensurable with their line of relevant expertise. Individuals outside the established research institutions may be equally qualified experts on certain aspects and should, therefore, lacking credentials, not be excluded from the debate. In some cases, it may be necessary to involve (representatives of) all stakeholders, in an “extended peer community” (Funtowicz and Ravetz [22]). However,

[6] Note that the definitions of horizontal and vertical integration are sometimes reversed. Note also that some prefer “horizontal integration” to mean integration between scientific disciplines, and “vertical integration” to mean integration between science and policy.

[7] For example, a decision maker is often interested in the distributional consequences of policies, particularly with regard to her electorate. In integrated assessment models of climate change and acidification, such issues are typically omitted.

[8] This may reflect a bias in the authors’ knowledge. Indeed, several readers of earlier versions of this paper have pointed this out, without, however, providing literature references. Papers discussing participatory methods are Cohen [12], Duerrenberger et al. [16], Jaeger et al. [34], Kasemir et al. [36,37], Ravetz [63], and van der Sluis and Jaeger [74].

[9] Examples are Klabbers et al. [39] for the Netherlands, and Cohen [11] for Canada, both on climate change.

scientists may have difficulty in accepting laypersons' opinions – as witnessed by the government review of the Second Assessment Report of Working Group III of the IPCC (cf. Tol [77]) – nor do laypersons necessarily accept the expertise of scientists. Investigation of the conditions under which such an endeavour can be successful is a topic of the EFIEA.

Participatory integrated assessment may also be restricted to scientists, usually in the form of expert panels.[10] This approach may be chosen if some components of the assessment cannot be modeled, if the models of the components do not fit together (see above for a number of reasons why models do not always fit), or if a modeling approach is not considered appropriate or adequate.

2.3.2. Integrated assessment modeling

As integrated assessment combines disciplines, Integrated Assessment Models (IAMs) consist of coupled "disciplinary" modules, or simplified forms thereof.[11] The respective disciplinary parts can stand alone and communicate with one another through exchanges of input and output data, or perhaps a common shell. The parts can also be integrated into a single computer code. The latter is preferable from a theoretical point of view, but may meet insurmountable practical difficulties. Differences in spatial and temporal scales, modeling concepts, data availability and quality, and maturity of disciplinary modules often make coupling and integration difficult or even impossible.

There are many ways to design an integrated assessment model. Various classifications of existing IAMs are conceivable and have been proposed. A major distinction is the way in which "policy" is brought into the IAM. IAMs can be policy evaluation or policy optimization tools (Weyant et al. [82]). Policy evaluation IAMs analyze the outcomes of proposed policy strategies.[12] Policy optimization IAMs advice decision makers by analyzing how certain goals can best[13] be accomplished.[14] Optimization models thereby not only evaluate policy strategies, but also select and judge them. Note that optimization can only be accomplished at the expense of a detailed representation of the system.[15] Policy optimization models tend to place more emphasis on economics; policy evaluation models tend to place more emphasis on the natural sciences.

A difficulty with both types of models is that, in most cases, the modelers, and not their clients, determine which variables are reported and how, and which objectives are optimized and how. Hence, it may happen that the modeler's answer does not match the decision maker's question. Not only does this mean that the decision maker does not necessarily get the full answer to the question, but the decision maker may also fail to recognise the mismatch between question and answer, for instance, because the differences between the model's jargon and the real world have not been made explicit.

Another distinction between the various current integrated assessment models is their treatment of uncertainty. Some modeling teams try to capture the underlying system as accurately as they can, resulting in very detailed models. The problem with this approach is that the resulting model is not necessarily as accurate as needed, particularly not for complex environmental issues on large spatial and temporal scales. Adding detail to a model implies an increase in computer time to run, and at the same time more parameters to be analyzed in a sensitivity analysis. Other modeling teams place uncertainty in the core of their endeavour,[16] trying to capture the range of possible directions in which the underlying system may develop. Note that uncertainty can only be properly analyzed by sacrificing the details of the model.

It appears that in both "evaluation versus optimization" and "best estimate versus uncertainty", the level of detail forms an important distinction. At first sight, optimization under uncertainty appears to be the proper approach to integrated assessment modeling – because evaluation is a special case of optimization, and best guess a special case of uncertainty. However, the amount of detail sacrificed is considerable, and may render the exercise futile to decision makers. One example of an optimization under uncertainty model is *SLICE* (Kolstad [40]); it operates at a global level – without distinguishing between various economic goods and services, income classes, nations, ecosystems – in time steps of ten years. Although the insights obtained with this analysis are substantial, it is clear that the insights can only be partial.

Since there is no single-best modeling approach, integrated assessment requires multiple modeling approaches – each with its strengths and weaknesses – to answer multiple questions and obtain multiple insights. An inherent problem

[10] Examples of this approach include the *MINK* (Rosenberg and Crosson [65]), and UKCCIRG [80] studies, on the impacts of climate change on one region.

[11] A proper simplified form contains all the essentials, but not the details of the larger model. Simplified models are also referred to as reduced form models, meta-models or computationally efficient models.

[12] Examples of policy evaluation models for climate change are *IMAGE1* (Rotmans [66]), *ESCAPE* (Rotmans et al. [71]), *IMAGE2* (Alcamo [1]), *AIM* (Morita et al. [47]), *GCAM* (Edmonds et al. [17]) and *SIAM* (Hasselmann et al. [25]). An example of a policy evaluation model for acidification is *RAINS* (Alcamo et al. [2], Amann et al. [3], Foell et al. [20]).

[13] Note that the definition of better and best is model-dependent.

[14] Examples of policy optimization models for climate change include *DICE* (Nordhaus [48–50]), *RICE* (Nordhaus and Yang [51]), *MERGE* (Manne et al. [44], Manne and Richels [45]), *CETA* (Peck and Teisberg [55–60]), *DIAM* (Grubb et al. [23]), *FUND* (Tol et al. [76,78]), and *CSERGE* (Maddison [43], Fankhauser [18], Fankhauser and Kverndokk [19]). An example of a policy optimization model for acidification is *ASAM* (ApSimon and Warren [4]); later versions of *RAINS* are able to minimize emission reduction costs given deposition targets (Klaassen [38]).

[15] A first attempt to build more complicated optimization models is Janssen's [35] *OMEGA* model.

[16] Examples of such models for climate change are *ICAM* (Dowlatabadi and Morgan [15]), *PAGE* (Hope et al. [28], Plambeck and Hope [61], Plambeck et al. [62]) and the model of Yohe and Wallace [84]. See also Funtowicz and Ravetz [21], Leimbach [42], Thompson [75], and van Asselt et al. [5].

with such a strategy is that the questions are answered by different disciplines in different languages. This becomes more complicated if the same, or similar words are used for different concepts. Making models comparable is a challenge for this reason, but there are more reasons underlying differences in modeling approaches. One such reason is the world views and scientific paradigms underlying the models. Models reflect the points of view and ideologies of the modelers; in most cases, this is a conscious process, but in others, it is not. Model differences originating from this cause could relate to the stability properties of the model (e.g., how large is the chance that a catastrophe occurs according to the model), to the metric to express impacts of environment and society (e.g., averages or maxima), or to policy instruments taken up in the model (e.g., tradeable permits or standards). A related reason why models may differ is that different modeling teams may interpret the problem differently, thus placing different stresses on various subproblems or even excluding areas which others see as crucial. Another cause for differences between models is the closure rule (e.g., optimization or simulation). A further cause for model differences is that technical toolkits vary, while technical fixes may have unexpected results.[17]

This diversity of modeling approaches is needed especially when there is no consensus on what the actual problem is, or many questions need to be answered. It does not suffice, however, to have diversity of model approaches. Within each approach, a diversity of models is desirable. This is to enhance creativity through competitiveness, to avoid institutionalized favours to the outcomes of particular models, and to allow for the robustness of results to be analyzed.

No matter how useful diversity may be, it should not create confusion or strife. Models and model outcomes should be diverse yet comparable. A major challenge for the integrated modeling community for the next period lies not so much in improving their models, but more in understanding what drives the outcomes and, particularly, the similarities and differences in the outcomes for different assumptions, different models and different modeling approaches. In "matured" modeling, model properties are well known and techniques to study the properties of new models are well developed. The immature field of integrated assessment modeling has yet to reach that level of sophistication. A model is nothing but a mapping from assumptions to results. If it can be shown that for any set of sensible assumptions a certain result follows, the result can be put forward as a policy advice (e.g., as a set of policy options and their implications). If, on the other hand, integrated assessment models can justify any policy, then in fact no robust advice can be given.

Robustness is not readily analyzed. The sensitivity of outcomes to perturbations of the model's parameters is examined in virtually all models, and in some cases in a structured and exhaustive manner. However, the specification of its modules and the structure of a model is as crucial as the choice of its parameters. The inverted pyramid issue (i.e., a number of integrated assessment models drawing on a single set of disciplinary studies), interpolation and extrapolation of data, the *ad hoc* treatment of the "softer" parts of the model, the relatively small number of integrated models, the wide diversity in modeling approaches, and the intransparancy of many models[18] make such an exercise rather hard. The current, unsatisfactory practice is to count how many models support a position, and how many do not. In addition, counterexamples are looked for, but the search process is rather *ad hoc*.

This unstructured approach has to be replaced by a more structured one for IAMs to be more credible and useful in decision making. In parallel to improvement of the communication of model outcomes and uncertainties (discussed below), an effort needs to be made to better understand model properties. Possible routes are linearization (e.g., Braddock et al. [8] for *IMAGE1*), so that approximate properties can be investigated analytically, or the use of alternative submodules per process (e.g., Janssen [35] for *TARGETS*).

2.4. Communication of results

The communication of the results of integrated assessments to the decision makers, be it in government, industry or elsewhere, can follow two alternative routes. The first is direct communication, i.e., presenting the analysis and its outcomes to the decision maker.[19] This is not a trivial matter. The abstract nature of a scientific analysis and its stylized representation of the issue are not readily compatible with the concrete problems of a decision maker. Question and answer do not necessarily match (see above), although the analyst may be tempted to convince the user that they do.[20] The main danger of this approach is that many caveats to the analysis, particularly those posed by other analytical teams,[21] get lost behind the colourful output and the vanity and need for funding[20] of the analyst. On the other hand, decision makers are sometimes eager to accept a particular outcome, for instance, because it fits with their prejudices, because it is an argument against a political or bureaucratic opponent, or because they are so uncertain that they want someone to tell them what to do.

In the second approach, communication with decision makers is indirect. Results are disseminated in the scientific literature. Through layers of intercomparison (as,

[17] Particularly if applied to problems outside the disciplinary expertise of the modeler.

[18] A few models are secret, most are not fully documented, some are enormously large, some are badly programmed, some are written in an unfamiliar programming language, some are documented in an unfamiliar tongue.

[19] See Hordijk [30] for acidification.

[20] Particularly if the user is (associated with) the financier of the integrated assessment endeavour. Note that this is not an imaginary situation, as integrated assessment is meant to be "policy relevant" rather than "fundamental" research.

[21] It is not imaginary that policy makers prefer to be advised by only one modeling team, for instance, from a national laboratory.

for example, by the Energy Modeling Forum or the Intergovernmental Panel on Climate Change) and independent, knowledgeable commentators, the results are supposed to be framed in the proper policy format by some consultant or analytically skilled civil servant. This approach is less direct and focused, but the advice is probably more robust and better thought through. In addition, analysts need less focus on window dressing, saving time and other resources to focus on substance. A potential drawback here is that decision makers cannot communicate their needs and concerns to the analytical community. The layer of interpretation and intercomparison should be ensured to work two ways, i.e., from science to policy, and from policy to science.

A drawback associated with the creation of a human, interpretative interface has to do with the great haste with which policy advice sometimes needs to be given.[22] Such haste is incompatible with this approach, particularly in case new model runs need to be made or new focus group meetings organized. This drawback can be lifted if analytical teams keep many alternative analyses in store, such as, for instance, as sensitivity and robustness analyses.

Whatever interface is chosen, it must be carefully designed so as to clearly communicate which results are believed to be robust, which results are debated or doubted, how particular results depend on "ethical choices" (e.g., value of a statistical life, time discount rate) and which results could not (yet) be obtained. The EFIEA will attempt to contribute to proper designs of science–policy interfaces.

In the communication stage, participatory integrated assessment compares and communicates the outcomes of (integrated) research. The outcomes of analyses cannot be taken for granted, but need to be screened for problem definition, underlying world view, used system for evaluating outcomes, and robustness and need to be compared to other studies' outcomes and to specialists' knowledge. This is a first step towards valuable policy advice. It is also a way to improve the scientific quality and acceptability of the analysis. In a second step, the advice needs to be communicated to the relevant stakeholders in a way that they can understand, accept and use. Both steps are hard to do with a fixed recipe, so a more participatory approach is advisable. Note that one of the outcomes may be a redefinition of the problem, or alternative problem definitions.

The Intergovernmental Panel on Climate Change is a prime example of an integrated assessment for communicating science to policy. It aims at a comprehensive, accessible and policy-relevant assessment of the myriads of issues around the enhanced greenhouse effect. However, although some standardization takes place, IPCC reports consist to a large extent of self-contained, monodisciplinary, academic review chapters. The complexity of the issue and the working group meetings do encourage people to look beyond the boundaries of their disciplines. The interface with policy making is through the joint preparation of the summaries for decision makers. Here, the communication is one-way: Scientists present their conclusions, and policy makers help phrase these in a digestible manner[23] – only in the government review, policy makers have some influence on the subject matter.

[22] Integrated assessment involves complex issues, so hasty decisions are ideally avoided.

3. Activities of the European Forum on Integrated Environmental Assessment

Above, many issues have been identified for improvement so that integrated environmental assessment can meet its potential. In many cases, this calls for continued research on and application of IEA. In other cases, discussion and information exchange are more appropriate means. It is here that the European Forum on Integrated Environmental Assessment is to play its role.

The EFIEA consists of two main work programmes and a number of miscellaneous activities. One work programme aims at improving the scientific quality of integrated environmental assessment. The methodology programme reviews and sharpens the tools with which knowledge can be integrated, be it in a model, an expert panel, an extended peer community or by any other means. This programme consists of a series of workshops on methodological issues. The other work programme aims at strengthening the interaction between science and policy. The policy programme reviews and sharpens the methods to define problems and communicate results in a three-way interface between scientists, decision makers and other stakeholders. It reviews a limited number of policy issues to which integrated assessment can contribute.

The EFIEA intends to organize three workshops in the methodology programme, and four workshops in the policy programme to be held interspersed over the period 1998–2000. In 2000, a concluding, major workshop will be organized. The EFIEA operates on the basis of inputs of its participants, and is financially supported by the Environment and Climate Programme of the Commission of the European Communities, Directorate-General XII.

3.1. Methodology programme

In the methodology programme, a sequence of workshops will be organized, each on a subject relevant to integrated assessment as a scientific activity. For each workshop, two background papers will be prepared, reviewing the theoretical state-of-the-art and surveying the application in integrated environmental assessment. The first workshop provided a broad overview of IEA and discussed its challenges and opportunities for the near future. Selected results can be found in this volume.

[23] Although drafted by scientists, the IPCC framework requires governments to endorse the policy makers summaries word-by-word. Emphases may, thus, shift and contentious issues may be rephrased or even removed. In principle, governments may not add language that is not covered by, or in contrast with, the underlying report.

Table 1
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Topics for the remaining workshops include:

- uncertainty;
- model analysis and comparison;
- scales;
- structural change;
- combining qualitative and quantitative analysis.

A brief description of the topics is given below. The important topic of quality assurance in IEA is a common theme throughout the methodology programme. The important topic of policy interface is the major theme of the policy programme.

3.1.1. Uncertainty

Issues to be addressed in an uncertainty workshop are: How can various types of uncertainty (parametric risk, structural risk, uncertainty proper, active ignorance, passive ignorance; see Wynne [83] for a better taxonomy) be included and analyzed in integrated assessment models? How to handle stochasticity and indeterminacy? How can the relationship with learning and structural change be properly handled? What roles are there to play for representative scenarios, fuzzy logic, non-linear dynamics, social learning, cultural perspectives, and post-normal science?

3.1.2. Model analysis and comparison

The main issue of a model analysis and comparison workshop is the question as to what drives the outcomes of the diversity of integrated assessment models? Subject to that, how can models from different approaches be compared? How do models compare to the disciplinary state-of-the-art? How do models compare to qualitative knowledge on the subject, perhaps held by laypeople? And, what are suitable techniques for answering such questions?

3.1.3. Scales

The main issue of a scales workshop is the incompatability between sustainability, which is a long-term, global matter, and short-term decisions at local to regional scales. How can scales be reconciled? What is the role for nested models? Can variable scales be used, and, if so, how to match the differences in natural discretizations between systems? Can different models be consistently used for different scales? Is linking through expert panels a suitable technique?

3.1.4. Structural change

The future will be different from the present, in obvious and unexpected ways, trivial and far-reaching manners. A structural change workshop would discuss how to deal with this in integrated assessment (modeling). What is the role of complex dynamic models? What is the role of multiple scenarios, multiple equilibria and bifurcations? How to distinguish between model artifacts and realistic outcomes? How can expert panels, or lay panels span a sufficiently wide future? What role can historical, or comparative international studies play?

3.1.5. Quantitative and qualitative analysis

A part of the existing scientific knowledge can be formalized into a numerical model, another part cannot. The main issue of a quantitative and qualitative analysis workshop is to find proper combinations of the two. How to avoid that quantitative results inappropriately dominate qualitative results, or *vice versa*? What roles are there to play for focus groups, extended peer communities, expert panels, delphi-methods, meta-analyses, scenario analyses, expert systems, neural networks and bounding exercises?

3.2. Policy programme

In the policy programme, a sequence of workshops will be organized, each on a subject relevant to integrated assessment as a policy advisory activity. The policy programme is strongly “demand-driven”. The first workshop focused on the methodology of communication between science and policy, reviewing particular techniques such as focus groups, use of models, and interactive assessment fora. Selected results can be found in this volume.

A recurrent theme in the sequel of the policy programme is the review of the application of the above-mentioned and other techniques in particular cases, by observing participants in (the preparation of) workshops and by follow-up surveys and interviews. Particular attention will be paid to problem structuring, and to communication of findings and insights.

The other workshops in the policy programme will focus on a topic in European policy making. A limited number of strategic policy questions will be posed to the relevant integrated assessment teams. The integrated assessors’ answers as well as their interpretation of the questions will be discussed in the workshop. The workshops will be attended by integrated assessors, decision makers, and selected stakeholders, where relevant, such as from NGOs and industrial and public sectors. Afterwards, selected decision makers and other stakeholders who attended the workshop will be interviewed as to their interpretation of the answers obtained.

Three workshops will be organized, possibly addressing:

- climate change;
- water (quality and quantity);
- transport (congestion, infrastructure urban air pollution, energy use, nature fragmentation).

The workshops will focus on questions such as:

- In what concrete way has integrated environmental assessment already played a role in European environmental policy? For example, has it been used to develop and agree on quantitative environmental objectives? Has it been used to stimulate additional research on key policy-relevant topics?

- Who are the key users in the policy making community of IEA? Elected officials, senior level civil servants, or their technical advisors? What branches of government have found IEA most useful? Environment, economic, agriculture, or energy ministries? How useful is IEA to NGOs and the private sector? Are there differences in use between topics, types of IEA, or IEA interfaces?
- What are the characteristics of IEA that make coupling science and policy a success? What characteristics do not lead to success?

4. Benefits

The potential benefits of the European Forum on Integrated Environmental Assessment are manifold. The most important ones are the improvement of the practice of integrated environmental assessment, with respect to both scientific quality and policy relevance. With the EFIEA, the practice of integrated environmental assessment will be better equipped to live up to its triple challenge: to be up-to-date with regard to disciplinary research; to be cutting-edge with regard to multidisciplinary integration; and to address the right policy issue in an understandable manner.

Tangible benefits include the publication of the results of the workshops. These publications will consolidate and improve upon the state-of-the-art of integrated assessment as a scientific endeavour and as a policy advisory activity. These publications will also set a standard of high quality, intellectually challenging and policy-relevant research on complex environmental issues.

Intangible benefits include the establishment of a critical peer community for integrated environmental assessment in Europe, and the establishment of a network of mutual consultation of environmental science and policy in Europe. Such benefits should spill over to communities other than the one of EFIEA. A critical peer community is the best assurance for continued high quality integrated environmental assessment. Similarly, the network of environmental science and policy will help to keep research policy-relevant, and policy well-informed. This latter aspect can be enhanced by allowing the EFIEA's network to be used as a rapid advice force.

The main economic and social impact of the establishment of a European Forum on Integrated Environmental Assessment is improved decision making on complex environmental issues, through the enhancement of the quality of debates.

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