DAFIA II — further development of data-flow analysis for integrated assessments

Jan Bakkes, Willemijn Tuinstra (eds.)
With contributions from:
Kit Buurman, Steve Nixon, Catherine Russell,
Jaap van Woerden

EEA Project Manager:
Hans Vos

European Environment Agency

Layout: Brandenborg a/s

Legal notice

A great deal of additional information on the European Union is available on the Internet.
It can be accessed through the Europa server (http://europa.eu.int)

ISBN 92-9167-414-1

European Environment Agency
Kongens Nytorv 6
DK-1050 Copenhagen K
Tel. (45) 33 36 71 00
Fax (45) 33 36 71 99
E-mail: eea@eea.eu.int
Internet: http://www.eea.eu.int

Preface

This is the final report of the DAFIA II project, written by WRc and RIVM as part of the EEA work programme. It contains the results of the second phase of a long-term project in which three phases of developing a data-flow analysis tool were originally defined (JRC-ISIS/EEA (1997) DAFIA-I Phase I — final report). The project has benefited greatly from the consultants' large experience with similar tools.

The work will continue on developing and implementing this data-flow analysis tool in the EEA's reporting. Web-based applications will be used to ensure full compatibility with the establishment of the European Environmental Information System. On completion of the full project the DAFIA tool should create an added value for the EEA by supporting the design of integrated assessments and by improving communication and data management in the assessment's execution.

Contents

Summary

DAFIA II encompasses the further development of data-flow analysis for integrated assessments. It focuses on the visualisation and documentation of data flows between the data-delivery and data-manipulation parties involved in future integrated assessment activities of the European Environment Agency (EEA). Visualisation allows an analysis of the data flow, which can be used for planning purposes, and to streamline and improve consistency of the resulting assessments. Moreover, once an assessment has been compiled, DAFIA II can be used to document and enhance the transparency of the different steps taken in the assessment process, the models used and the parties involved in the different steps.

This report will provide a further look at the data-logistic process for integrated assessments, with suggestions on how data-flow analysis can clarify this process. It discusses the criteria for the selection of a data-flow visualisation tool and makes recommendations for data-flow visualisation for integrated assessments in future.

The investigated available software does not appear to offer an out-of-the-box solution for a data-flow visualisation tool. Commercial packages aimed at data-flow modelling for IT development are not really suitable because of their complexity. What is needed is an open data-flow chart tool that can easily be customised. The IEA-explorer (based on Microsoft Office components and now in development in EEA and at RIVM) is a much simpler software package to use. The DAFIA II project team therefore proposes the 'integrated environmental assessment (IEA) explorer' as the standard data-flow visualisation tool for EEA (future) integrated environmental assessments. For EEA purposes the IEA-explorer would run under the name 'DAFIA'.

Data-flow analysis can be used in two complementary modes: 'design mode' and 'documentation mode'. In the design mode flow charts reflect a desired situation, while in the Documentation mode they present an actual situation. Within the design mode the emphasis is on the use of the flowcharts for planning purposes at a point in time when an integrated assessment process is still in the set-up phase. The data-flow charting can be used to create a blueprint of an integrated assessment system as an 'ideal' system of indicators, models and data, and change it to reflect comments, evolving insights and making decisions anew. The traceability (= quality) and data availability aspects are most important in the documentation mode. In its documentation mode tools like IEA-explorer can be used for monitoring and tracking with the aim of improving reporting process efficiency and transparency.

The possibilities of the data-flow analysis approach have been further explored and presented here using elaborated data-flow charts for air pollution and climate change. The data-flow charts are based on work recently carried out on integrated assessments for air and climate change (EEA, 2001a)). A more detailed view of four indicators related to climate change (water stress, change in permafrost, erosion sensitivity and change in growing season), as well as one driving force (transport), is also included.

Recommendations to EEA for further development of DAFIA:

- data-flow visualisation tools should be manageable for those who do not have IT experience
- in the design mode, give priority to supporting interactive communication, e.g. through project team meetings;
- in the design mode, focus the data-flow analysis on transfer of data sets between parties (paying less attention to internal data-flows within, for example, the network of a particular European Topic Centre);
- in the documentation mode, use the data-flow charts to connect to existing information systems rather than setting up yet another information system.

1. Background and development of the project

1.1. Introduction

The European Environment Agency (EEA) commissioned WRc and RIVM to further develop data analysis for integrated assessments, following on from the results of DAFIA I, a pilot study of global information and data-flow identification.

DAFIA I showed that data-flow analysis could improve the efficiency of reporting and transparency in data input and assumptions among the different environmental issues being considered.

DAFIA II focuses on the data-flow needed for scenario and prospective analysis and, in particular, the role of the European Topic Centres (ETCs).

Communication among the EEA and its partner institutions, ETCs, in Eionet in its assessment and reporting work is highly important. Communication can be improved through better structuring, organisation and documenting of the main elements of the reporting process i.e. data files, indicators, models and scenarios.

One of the first steps is to document and visualise data-flows during the assessment processes by way of 'data-flow visualisation'. This will make an analysis of the data-flow possible, which can be used for planning purposes, and to streamline and improve the consistency of the resulting assessments. Furthermore, it will help to clarify the roles of the different participants involved in the process, to identify links and to organise work-sharing. Data-flow charting can also play a role after a certain assessment has been finished by way of documenting the different steps in the assessment process; it can also provide easy access to data.

The overall objectives of the DAFIA II project are to:

- advise the EEA on the selection of an appropriate project management tool to support communication between different actors in assessment processes;
- identify and describe information components (sources, flows, processing) for integrated assessments by the EEA, in particular, for the next State of the Environment and Outlook planned for 2004/5 (Working title: SoEOR 2004);
- visualise the data-flow using appropriate tool(s) and thereby provide a basis for the EEA to improve the efficiency, consistency, transparency and understanding of the process of regular integrated reporting; monitor its reporting process; and organise the stepwise expansion of the scope of its assessments;
- evaluate the findings and recommend steps towards future assessments.

1.2. Tasks

Original tasks
The DAFIA II project was originally divided into a number of tasks as outlined below:

Task 1 — Identification of the data-flow
This task was to identify the necessary data-flow for all relevant socioeconomic and environmental issues, with the right kind of attention for the steps in the analysis, the models used and any necessary data manipulations. This task was to be carried out in cooperation with relevant EEA project managers and ETCs.

Task 2 — Description of steps in the data-flow and creation of a database
A database was to be constructed and equipped with information gathered in Task 1 to provide a clear view of the process and suitable for use by those engaged in scenario and outlook development. The meta-information standard was to be structured according to forms that have been used in practice by WRc and/or RIVM. Simplicity was a priority.

Task 3 — Visualisation of the data-flow
Task 3 was to select a tool for visualising the data-flows identified in Task 1. The tool would be selected following consultation with EEA's information and technology services (ITS) department and be simple enough to address the needs of the many partners working at a distance. This tool would then be used to produce data-flow charts for the issues identified in Task 1. In particular, the charts were to address cross-linkages and facilitate communication and provide an overview of the process.

Task 4 — Analysis of data-flow and recommendations for future assessments
The data-flows identified were to be analysed with the aim of making practical and relevant recommendations, addressing the interdependencies between ETCs, the need for consistency in sectoral projections and the requirements for information on scenarios for non-EU countries.

Task 5 — Monitoring and tracking procedure
The final task was to develop a suitable monitoring and tracking procedure with the aim of improving reporting on process efficiency and transparency. This was to be based on RIVM's practice and experience, adjusted to meet the requirements of the project.

Adjusted tasks agreed at the project inception meeting
At the project inception meeting on 14 February 2001 the original tasks were slightly modified, although the overall aims and objectives within the DAFIA II project remained the same all through the project. However, in light of other EEA activities, and timing and availability of the required information, it was decided, in consultation with the EEA, to modify the approach of the project and change some tasks accordingly. The limited project budget also played a role here.

Introduction of a prototype phase
The first step in Task 1, as stated in the technical annex of the contract, was to determine the socio-economic and environmental issues for air and climate change; water, waste and material flows; nature and biodiversity and the terrestrial environment; data flows need to be identified for these issues. Issues supporting indicators would be used for prospective analyses in the SoEOR 2004.

The project inception meeting in February 2001 established that ETCs would be required to produce a core set of indicators for environmental issues as part of their work programmes. To ensure that DAFIA II would complement existing activities within the EEA, the EEA itself made the core set of indicators a starting point for this project.

However, the new ETC contracts were not foreseen to commence before March/April and the core set of indicators would not be available within the timescales of the DAFIA II project. The EEA therefore decided to develop a prototype, which would be used initially until draft or core lists of indicators had been developed by the ETCs.

Selection of one working area as an example
Instead of a full analysis and visualisation of the data flows within all working areas of the EEA one working area has been selected to be elaborated as an example. It was decided that the prototype would be based on work recently carried out on integrated assessments for air and climate change (EEA, 2001a). This work involved the modelling and data-flow analysis of the environmental issues relating to air and climate change, and will be built upon by the European Topic Centre for Air and Climate Change (ETC-ACC) as part of its 2001 work programme.

Selection of one driver in the area of air and climate change: transport
Transport was selected as a prototype sectoral issue. Transport is a well-documented driving force associated with a number of environmental issues, including air and climate change. This sector has been widely explored in the EEA transport and environment reporting mechanism (TERM). It is also a relevant sector for prospective analysis in SoEOR 2004 because of its strong and persistent growth.

Adjusted tasks according to the interim meeting
The interim report was presented to the EEA meeting of 5 July 2001, where the proposed approach to, and the tentative choice for, the IEA-explorer were accepted. It was also decided to carry out the following tasks in the time left in the project:

- describing RIVM's experiences with data-flow visualisation tools and the reasons for developing the IEA-Explorer (see § 2.3);

- extending the application of the tool to air pollution and climate change on the basis of the work done in the ShAIR project (see § 3);

- exploring the 'periphery' of the air pollution and climate change field by elaborating some impact indicators and the interlinkages of data-flows in the relevant environmental issue (ETC) areas. (see § 3.3).

Furthermore, the EEA also showed interest in getting a demonstration package installed locally on EEA staff PCs for exploring the possibilities and difficulties of the tool. This package would be accompanied by a short manual.

Clearly, it would be important to separate:

- data-flow charting in support of project design and planning

from

- data-flow charting documenting an ongoing assessment.

As, at the time of the project, the ETCs were still in the phase of elaborating the practical side of their tasks and roles, it was not appropriate to conduct a parallel study on the design of desirable data-flows. Rather, DAFIA II should show how data-flow analysis could play a role in future design processes.

The current report
This report describes the findings of the entire project. Chapter 2 introduces the IEA-explorer; Chapter 3 shows an example of how the IEA-explorer is applied and flow charts elaborated:

- for air pollution and climate change;

- for transport as a driving force;

- for four indicators:
  — freshwater stress;
  — change in permafrost;
  — erosion sensitivity; and
  — change in growing season.

Finally, conclusions are drawn, and suggestions are given for possible extensions of the DAFIA II project and subsequent steps to be taken.

2. Approaching data-flow analysis for integrated assessment

This chapter first provides a look at the data-flow process for integrated assessments. Secondly, it gives suggestions on how data-flow analysis can clarify the data-logistic process. The criteria for selecting a data-flow visualisation tool are then discussed, followed by a presentation of the software tool that at present seems to meet these criteria best. Finally, recommendations are made for the future of data-flow visualisation for integrated assessments.

2.1. Data-flow analysis for integrated assessments

The process of producing an integrated assessment (such as the SoEOR 2004) is highly complex, requiring the cooperation of many parties and people. Besides the obvious process of writing the report, a major part is the 'data-logistic process' which constitutes, in fact, the reality of data and documents being transferred from one institute to another and from one person to another. In fact, these broad-based assessments tend to be so complex that data transfer arrangements between the collaborating organisations can only be worked out gradually; they are also subject to change as the project progresses. It is this part of the integrated assessment process to which data-flow analysis can be applied, and on which the DAFIA II study concentrates.

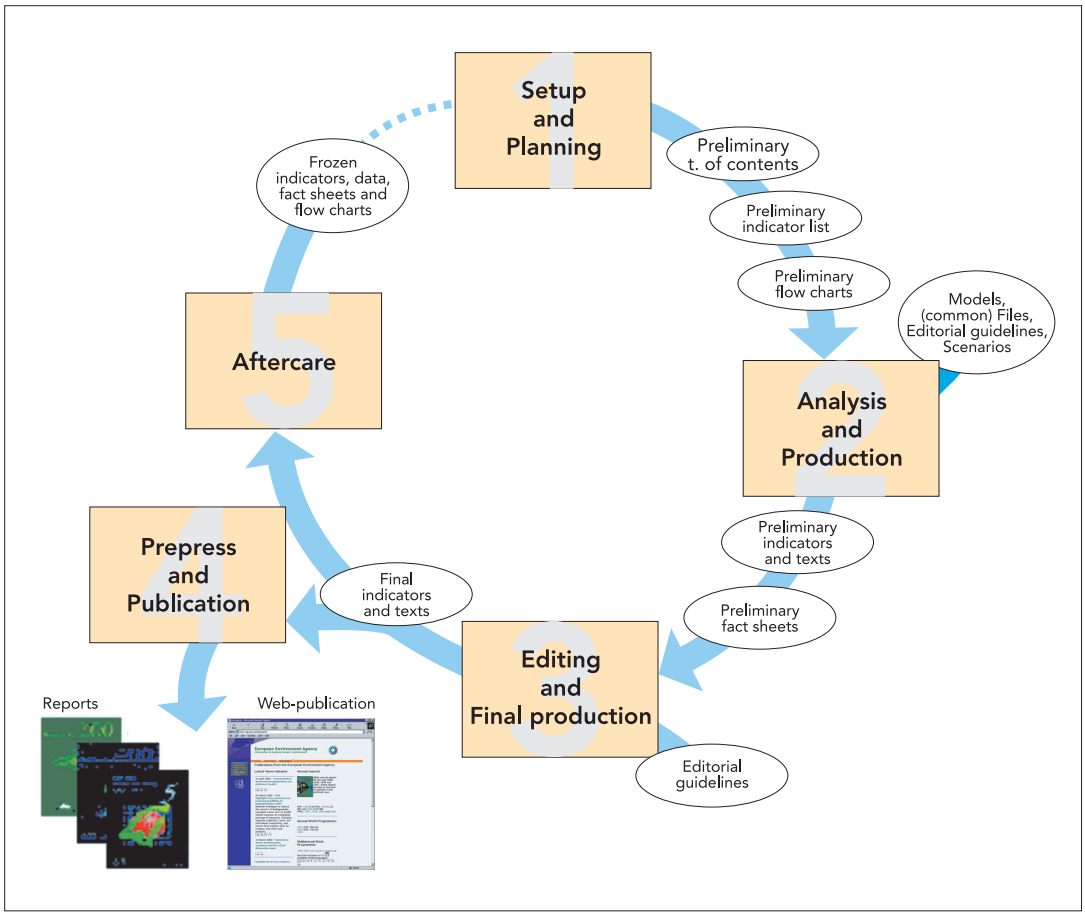
2.1.1. The data-flow process

The data-logistics process is aimed at providing the right numbers, tables, maps and charts at the right time with the right quality to the right people in the organisation. Flow charts can provide an overview of this complex data-logistic process and can play a role both in the planning stage of an assessment, and in the final stage, when documentation and traceability of the information become issues. In selecting a data-flow visualisation tool for this process, it is necessary to understand how this works in practice. The illustration below and the following description gives an idea of how the data-flow process could, or perhaps should, work in practice.

The five phases (Figure 2.1) of a typical data-logistic process are described in general terms in the following section, along with the tasks performed — in theory at least — by the different parties (a project management team, an editorial team, and other project participants) during this process. The description covers a rather hypothetical, ideal situation, but at the same time outlines the major functional steps of ongoing environmental assessments, including outlooks, using the Netherlands as a practical example.

Figure 2.1. **The five phases of a typical data-logistic proces**

Source: RIVM, CIM-Factsheet 28 Ondersteuning Productielogistieke Proces



1. Set up and planning

After a relatively creative starting phase, in which the basic ideas of the integrated assessment report at hand are formed, the project team usually establishes a preliminary table of contents. This table of contents is then further elaborated into an indicator 'wish-list'. Together with thematic experts, the project team sets up an initial flowchart in which the necessary data, indicators and models are visualised. The project team also determines which scenarios (or 'cases') are to be examined. The flow charts are a starting point for the data-logistic planning and the timely preparation of models and data. What model should be run at what time using what data to deliver all the indicators needed in time? Indicators and flow charts from earlier publications are often used to facilitate and clarify the process. The project team might appoint a data-logistic manager, who coordinates data-logistic issues and assures the maintenance of the flow charts during the assessment work.

2. Analysis and production

In this phase (which may last a year or longer), models are applied and/or data are processed as planned in the different steps in the flow charts. Prior to production, experts specify the scenarios and (common) files, and make them ready for use. Shortly after carrying out the analysis, the expert justifies the calculation process in a fact sheet, and attaches the resulting data to the data-flow chart (note that this last activity is already part of the documentation of the integrated assessment process and represents a first step towards aftercare). The flowcharts are very useful in this phase because they facilitate the communication between the project team and all other relevant participants in the process about what needs to be done and who is involved. Typically, a handful of revisions takes place as various themes and steps in the causality chain come into play and improvements and work-arounds are introduced. The research experts produce a preliminary indicator based on guidelines from the editorial team. The data-logistic manager keeps the data-flow charts up-to-date, and checks progress. The calculated results function as a basis for the report text.

3. Editing and final production
The editorial team keeps the indicator list up-to-date, and communicates the list with all project participants. These participants deliver the preliminary indicators for central storage. When all indicators have been handed in, they are harmonised and adapted according to the editorial guidelines. Any changes in the indicators are made in consultation with the project manager and project members involved.

4. Pre-press and publication
The editorial team prepares the texts, graphs, tables, maps etc. of the indicators for printing or publication on the Internet. The printer's proof or drafts are checked for graphical correctness and consistency with the accompanying text.

5. Aftercare
After publication, the editorial team freezes and archives the indicator list. The data-logistic manager collects, validates and freezes the specification and values of the indicators, the underlying data sets, fact sheets and flow charts. This information can be kept on-line through the data-flow chart system. It may be used for archiving and other quality assurance or quality control requirements, for publication on the Internet and for use in the future, e.g. integrated assessment activities, derived publications and presentations and/or other relevant projects.

2.1.2. Why use data-flow charts?
How do data-flow charts fit into the data-logistic process?

The main goal of the data-flow charts is to register what data and models are being used in an integrated assessment project and by whom, and to allow for easy access.

Why this overview?

Design and planning
1. To support internal communication with project contributors. Everyone involved can view the architecture, components and results of the assessment, and, if desirable, download them. Everyone can see which model chain will be used for the calculations and which scenarios and assumptions form the basis for these calculations.

2. To provide a survey of the complexity of the modelling process both prior to the actual calculations for planning and during the calculations to ensure progress.

Documentation and tracking
3. To allow traceability of data-flow throughout the model chain (high level). This traceability forms the basis for justifying the results. The application provides access to detail-level traceability of data and fact sheets, accounted for in the quality systems of participating organisations or organisational units.

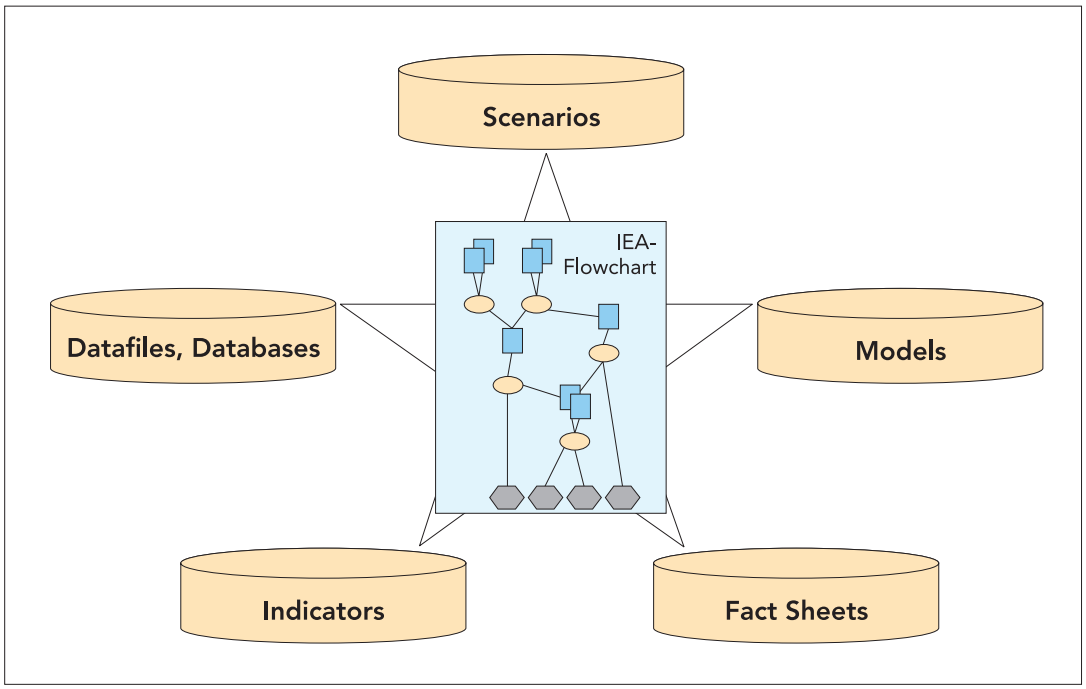
4. To make data available after the project. Usually, the data of an integrated assessment will be used later in other projects.

In the data-logistic circle described above, a data-flow tool can be applied, especially in phases: 1. (set-up and planning), 2. (analysis and production) and 5. (aftercare). In phase 1, the emphasis is on the use of the flowcharts for planning and design purposes. In phase 2, the flowcharts are useful for checking progress and for internal communication. In phase 5, the traceability (= quality) and data availability aspects are the most important.

The data-flow tool provides one point of access for all kinds of project information, like a spider in a web (Figure 2.2). However, it should be kept simple and compact in order to make it really useful for those involved. If necessary, supporting tools like databases and modelling documentation systems can be accessed by a simple link from the data-flow tool.

Figure 2.2. **One point of access for all types of data**

Source: RIVM, CIM-Fact sheet 22: MPB-explorer: overview of integrated assessment data-flows



2.2. Criteria for selection of a visualisation tool

Now that we have seen how data-flow charts can be put to use in an integrated assessment project, let us take a look at selection criteria for the data-flow visualisation tool.

2.2.1. EEA requirements

The EEA requirements for the data-flow visualisation tool were published in the DAFIA II call for tender. These requirements stated that such a software tool should: be adequate for regular updates by the participants in the assessment;

- be user-friendly for a wide range of users;
- enable visualisation of the steps during the data-flow and indicate models used and other kinds of data manipulation;
- be able to indicate the necessary input data and the derived output data;
- consider meta information of the data-flows, models, etc;
- be applicable in a Windows-PC surrounding.

2.2.2. RIVM experiences using data-flow analysis tools 1991–2001

RIVM was one of the first organisations to compile fully-fledged integrated environmental outlooks in the second half of the 1980s. Initially, the framework was to integrate monitoring and modelling, to make a diagnosis next to a prognosis and to obtain more information at less cost.

In 1988 the first national outlook of The Netherlands was published (RIVM, 1988). The second outlook (RIVM, 1991), aimed at a more thorough quantitative assessment using substantially increased resources, an explicit government mandate, and a network of 12 government expertise centres. After this second outlook was released, a sizeable effort was put into documenting exactly how the outcomes had been derived in order to consolidate the methodology (Bakkes et al., 1991a,b). This post-mortem revealed unacceptable gaps in institutional memory and shortcomings in the coordination of scenario implementation across the various models and partners. This then led to a major effort to establish a grip on data specifications, model coordination and data flows through the analytical system.

Both the ex-post analyses on the second national outlook and the ensuing management effort used SDW (systems development workbench) software and schematisation techniques. They were combined with meta-information systems for input data and models.

By the middle 1990s, the data-flow schemes for RIVM's national outlooks had been fully developed into handbooks. They featured no less than 100 000 determinants (selection of variables *x* their specifications). This number could later be squeezed somewhat, to 70 000. In addition to the data-flow charts, central delivery platforms were eventually set up as hubs in the assessment compilation. These platforms had the desired output format built in, and ensured traceability in a rigorous and detailed fashion. The tracking procedures, in particular the data-flow charting, posed a sizeable administrative burden. More important, adapting the system to reflect the realities of the next edition of RIVM's national outlook posed an impossible repetitive task. In fact, project managers experienced the system as a burden rather than a support. Clearly, a gap had emerged between data-flow management and the creative compiling of an outlook. The data-flow modelling tool which was used, SDW [see SDW] proved to demand too much detail and too much professional IT background (see also § 2.3.1)

During the second half of the 1990s, the variety of national outlooks required from the RIVM increased markedly, with specific reporting guidelines for environment, nature, spatial issues and liveability, as well as an ex-ante evaluation of large investment schemes. This multiplied the number of assessments to be produced each year, while also increasing the interactions with other organisations. For example, national nature outlooks are, by law, required from RIVM, but 90 % of the input is delivered by other organisations.

Against this background of a continued and increased need for an overview, untenable size of IT-based data-flow management tools and more variety in assessments, RIVM has recently embraced the much more project-oriented approach towards data-flow analysis as described here. The integrated environmental assessment (IEA-) explorer has been introduced. Key features are:

- data-flow charting as the main tool of a project manager;
- *communication* as 'the name of the game' here; should be used in preference to *grip* on the assessment;
- software and schematisation techniques selected to make data-flow analysis as 'easy as pie', in particular in the 'design' mode; however, sacrificing some strengths of IT-oriented tools, such as rigorous checks between levels;
- maintenance of existing meta-information systems, such as a model catalogue, with their interfaces improved.

By the early 2000s, public debate about the reliability of RIVM's national assessments had erupted. This triggered an ambitious RIVM campaign to increase transparency and external review, conferences on methodology to accompany the release of important assessments, systematic thinking about uncertainties, and access to meta-information and validation results. The data-flow charts (now more plausible, because they are kept up to date in cooperation with the experts carrying out the assessment) are, at present, a valuable tool for presenting background information after an assessment has come out.

2.2.3. Additional requirements based on RIVM experience

Experience with data-flow visualisation at RIVM in the past 10 years or so has yielded very similar requirements to those formulated by the EEA for DAFIA II:

- Keep it simple!
  Use easy-to-follow drawing techniques. Anyone involved in making integrated assessment (mostly researchers) should be able to read the flowcharts without prior specific ICT knowledge or education.

- Easy exchange of data-flow charts
  Clear communication, the most valuable aspect of flowcharts, also implies that the flowcharts should be easy to exchange and adapt for any of the project staff. In this way the flowcharts will keep reflecting the actual situation. Users should be able to send the flowcharts by e-mail and adapt them using standard software.

- Customisable software, open standards
  The flowcharts are the 'spider in the web', the connection between such project elements as scenarios, data, meta information, fact sheets, model descriptions and project planning. To fulfil this central role, flowcharts will have to be linked to these project elements, which will surely arise from different sources. To make these diverse links, the visualisation tool needs to be embedded in an open, customisable software environment.

- Use of internet
  Do not keep the flow chart as a paper copy or as a file on a PC: Put it on the Internet or at least on your Intranet, along with the other project documentation! The role of the Internet as a facilitator for inter-organisational workgroups is now unquestionable, as we have experienced through the development of the Eionet telematic network over the last couple of years, and its extension into an 'e-Eionet' (Eionet, 2000).

2.3. Selection of a data-flow visualisation tool

What are the tools available on the market that meet the criteria listed above? The following section will take a look at several tools available on the commercial market, followed by a first glance at the dedicated software tool developed in-house at RIVM. This will be followed by recommendations.

2.3.1. Software available on the market

In the evaluation of the DAFIA I project the use of tools available in the market was suggested. Due to limited resources, it was not feasible in DAFIA II to scan the whole commercial market. Instead, and as suggested in the DAFIA I report (Post and Wieringa, 1997) tools like 'Rational Rose' (Rational Rose, 2001), 'ABC-flowchart' (Igrafx Flowcharter, 2001) and 'System Architect' (System Architect, 2001) were considered.

During the earlier national environmental reporting activities (1991–95), RIVM had been using the data-flow-modelling tool, SDW, from Cap Volmac (SDW, 2001). Despite substantial effort, maintenance proved impossible because of the high level of detail and because users were not familiar with the type of diagrams and the professional language used.

Like SDW, Rational Rose and System Architect are professional IT-packages used for the different phases and diverse needs of IT development projects. These tools work with data-flow charts but are not sufficiently user-friendly for a broad selection of users because the generation of flowcharts is highly complex — typically meant for use by computer professionals for information modelling. Another drawback is that the tool software is not sufficiently customisable, deemed necessary, for example, for attaching a diverse range of documents and meta information to the data-flow charts and subsequent storage in a database. The software package 'Igrafx Flowcharter' (formerly known as 'ABC-flow chart') seems to fit most of the criteria for the visualisation tool. It produces easy-to-use flow charts, is customisable, and can be used to export files to Internet. However, a package licence is needed for editing the flowcharts contained in this product. This demand could hamper widespread use of the software by a large and diverse user community. Also, the product still needs to be customised to fully meet the needs of the integrated environmental assessment work.

2.3.2. Conclusion

The investigated software available on the market does not appear to offer an out-of-the-box solution for a data-flow visualisation tool. Commercial packages aimed at data-flow modelling for IT development are not really suitable because of their complexity. What is needed is an open data-flow visualisation tool that can easily be customised.

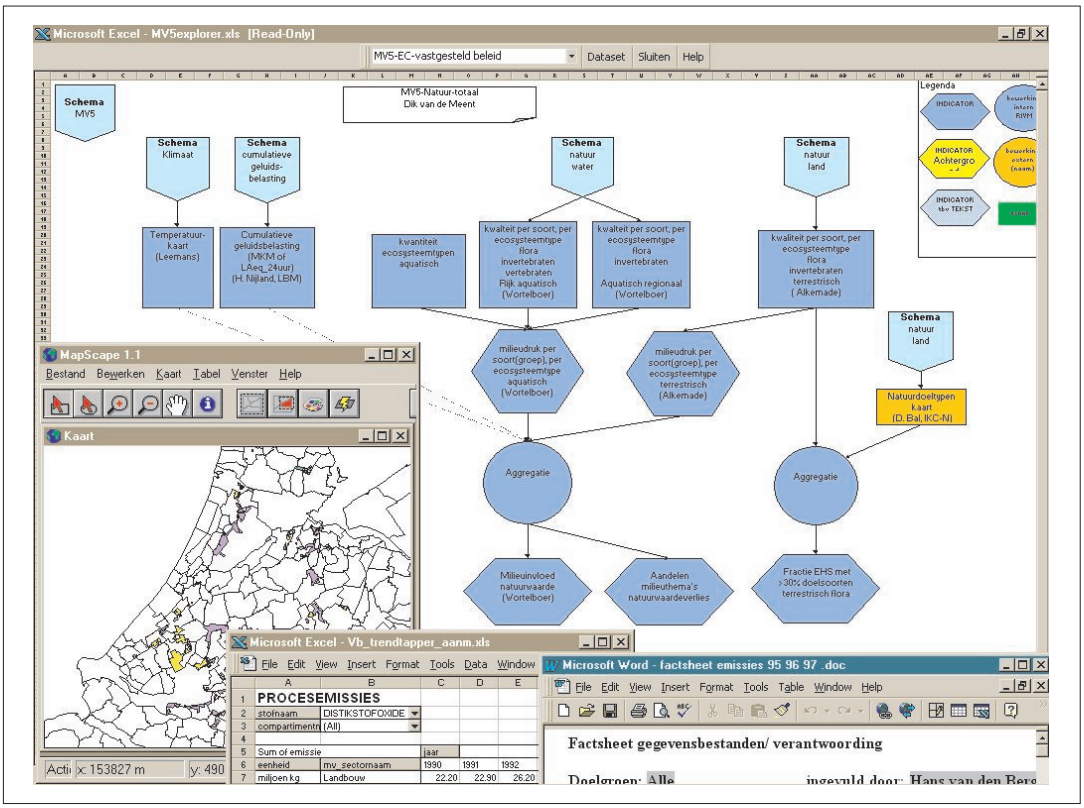
2.3.3. IEA-explorer: RIVM's current data-flow visualisation tool

RIVM has several years of experience in using data-flow visualisation tools for integrated assessments, in particular, for producing the national environmental balances and outlooks. Having started with the relatively powerful and specialised software package, systems development workbench (SDW) some 10 years ago, RIVM has now switched to a much simpler software package under development in-house and labelled the IEA-explorer. This package is fully based on Microsoft Office components (MS-Access, MS-Excel and MS-Word).

In the IEA-explorer, the steps in the reporting chain are presented in a data-flow chart (see Figure 2.3). Data and data descriptions (e.g. fact sheets) are accessed by clicking on one of the elements in the chart. Collectively, the data-flow charts and data provide an overview of the modelling process at any point during the assessment process. This overview offers a firm base for project planning, communication and quality control of the information components.

IEA-explorer view with an example in Dutch from the Netherlands: Flow charts provide access to maps, data and fact sheets

Figure 2.3.



Source: RIVM, CIM-Factsheet 22: MPB-explorer: overview of integrated assessment data-flows

The IEA-explorer, although not available on the market, appears to come closest to the requirements listed above. It fulfils the EEA requirements by being:

- *Adequate for regular updates by the participants in the assessment*
  IEA-explorer has been specifically designed for this. With one press of the button a new flowchart can be synchronised with the database, while ensuring that no data is lost.

- *User-friendly for a broad selection of users*
  Data and meta data can be easily attached to the flowchart. Pick lists and familiar dialogues make use of the visualisation tool easy.

- *Able to visualise the steps during data-flow and indicates the models used and other kinds of manipulation of data.*

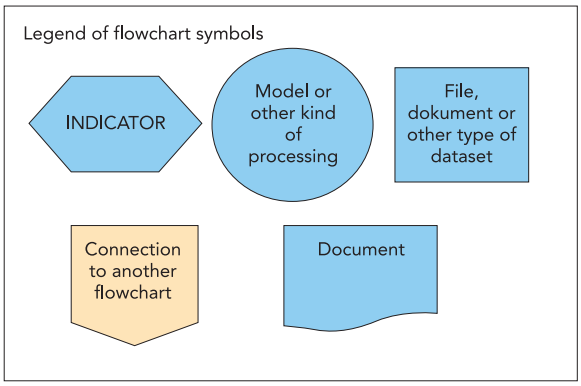
- *Able to indicate the necessary input data and the derived output data.*

- *Able to consider meta information of data-flow, models, etc.*
  Meta information of files and indicators is stored in a database. Other meta information, stored in documents or databases, can be linked up with it.

- *Applicable in a Windows-PC environment.*

The IEA-explorer can also be said to meet the additional requirements outlined in §2.2.3:

- *Keep it simple!*
  The data-flow charts are made using the standard MS-Office drawing toolbar. Only four elements ('AutoShapes') are used: an oval for models, a rectangle for data, a hexagon for indicators, a pentagon as a connecting symbol to link to other elements or flow charts, and a document symbol. This simple 'draw-on-a-napkin' functionality has proven easy to follow for most people involved. ([1])



- *Easy exchangeable data-flow charts*
  Since Microsoft Office is a de facto standard, the data-flow charts are easily exchangeable.

- *Customisable software*
  The data-flow software is customisable using Visual Basic.

- *Use of the Internet*
  In the later versions of IEA-explorer, the charts and indicator lists of integrated assessment reports can be published on the Internet.

2.3.4. Recommendations

Given RIVM's positive experiences, the simplicity and user-friendliness of the product, and because it matches the requirements above, the DAFIA II project team has proposed the IEA-explorer as the standard data-flow visualisation tool for the EEA's (future) integrated environmental assessments. For the EEA the IEA-explorer would be used under the name DAFIA.

2.4. Data-flow analysis within the EEA network: two complementary modes of use

As described in § 2.1.2, flow charts can be used for different purposes in different stages of calculating the assessment process. DAFIA (EEA version of the IEA-explorer) could be especially helpful for the EEA in the set-up and planning phase and in the aftercare phase (see term in §2.1.2).

2.4.1. Design mode

In the design mode the emphasis is on the use of the flow charts for planning purposes, specifically by managers of the 'large' assessments (e.g. the SoEOR 2004), to connect the environmental area assessments, including the ensuing interlinking flows and models, and to create an overall framework of the assessment. The data-flow charting can be used to create a 'road map' of the integrated assessment project to which all project managers and ETCs in principle should adhere. Typically, the flow carts change frequently in this mode.

This 'design' mode of data-flow analysis requires simplicity and should not go into too much detail. The emphasis is on support to setting the project up and keeping track of progress and changes. In the design mode the data-flow analysis should take place on the level of the transfer of data sets from one responsible unit to another. Details beyond this can be left to the management of ETCs and comparable entities. They will only appear in flow diagrams in

(1) For EEA purposes it is recommended to add an element representing a European Topic Centre (ETC).

a later stage. Typically, in this mode of data-flow analysis, project managers and ETC leaders use it to make visible and communicate their demands of data from 'adjacent' environmental fields. For example, the amount of biodegradable waste dumped (ETC Waste and Material Flow (ETC-WMF)) as an input for assessing greenhouse gas emissions (ETC-ACC).

In particular DAFIA can play an important role as a tool to support discussion in working groups at various stages. The data-flows identified can be analysed with the aim of making practical and relevant recommendations, addressing the interdependencies between ETCs, the need for consistency in sectoral projections, and the requirements for common scenario elements.

Given the nature of the EEA organisation and its network, data-flow analysis for integrated assessment has a role to play at different levels in the EEA activities. For example, the organisations that work together in an ETC can organise their ETC work in more detail than would appear in the overall design of SoEOR 2004. At this deeper level project managers and ETC leaders would use data-flow analysis to support the organisation of the indicators and data flows in their area (e.g. ETC Water (ETC-WTR), using the tool for creating an overview of its water indicators).

As the work on indicators and data in the several environmental (ETC) fields develops, any new 'large' assessment should lead to a new overall framework. The environmental issue frameworks will evolve and converge through time, resulting in an overall framework, which in view of continuously changing insights and priorities will, however, be dynamic.

2.4.2. Documentation mode

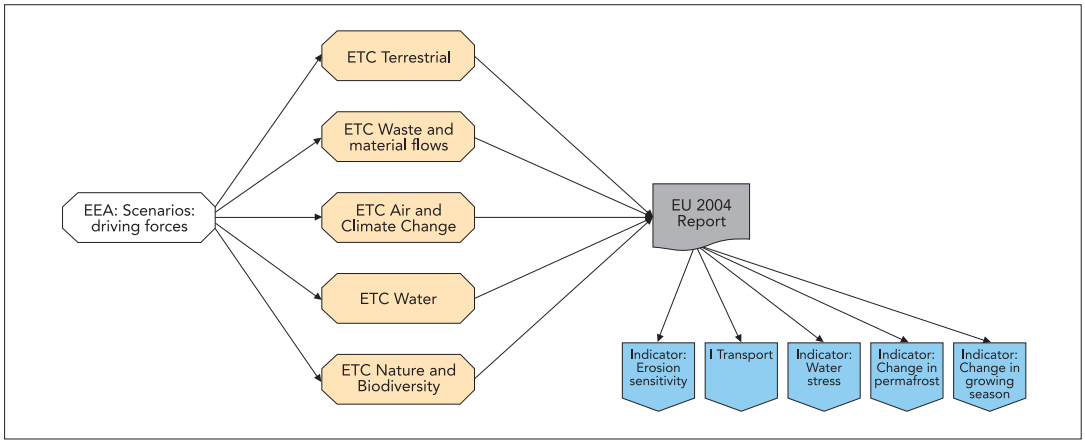
In the documentation mode the traceability (= quality assurance) and data access aspects are most important. Data-flow analysis in this mode supports outward communication and transparency in integrated assessment processes by using flowcharts to show the role of models, indicators and data. As well, data-flow analysis provides access via the data-flow charts to background documentation (model descriptions, fact sheets documenting how calculations were done) and to actual data underlying the assessment.

3. Examples of four indicators and a driving force in air and climate change

In this chapter we explore the possibilities of DAFIA by presenting flowcharts for four indicators and one driving force related to the area of air and climate change. The flowcharts based on research recently carried on integrated assessments for air and climate change (EEA 2001a; the ShAIR report) This work involved the modelling and data-flow analysis of the environmental issues relating to air and climate change and will be continued by the European Topic for Air and Climate Change as part of its 2001 programme.

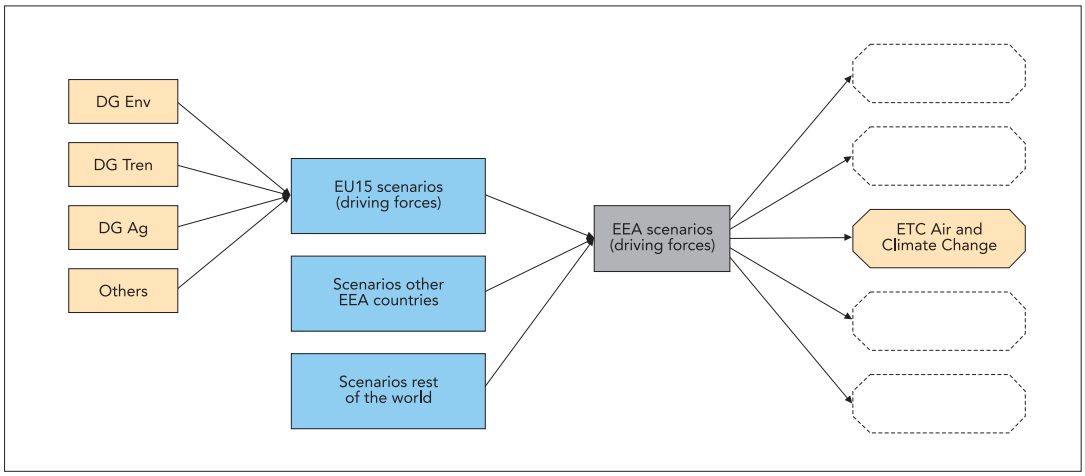
The flowchart below represents a general picture of the relationship between the EEA and its ETCs, including the reporting. The arrows represent data flows. The pentagons represent example indicators elaborated in this report.

Figure 3.1. **EEA Flow chart and its relationship to the reporting for SoEOR 2004**



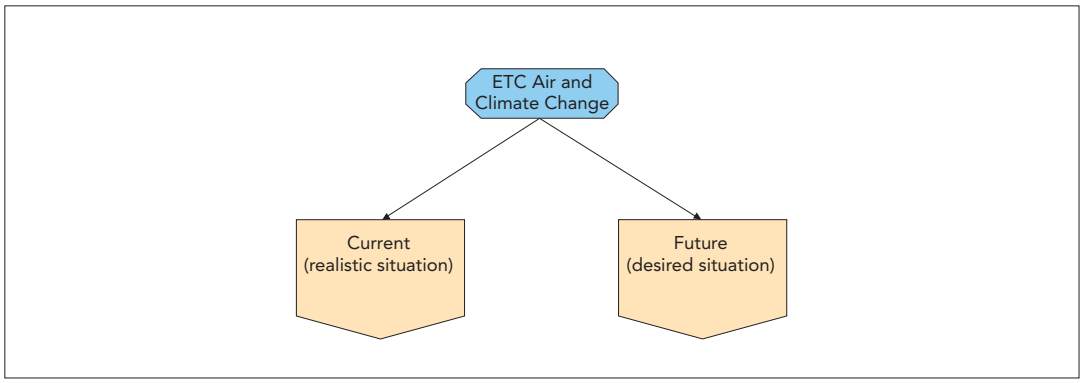
For the ETC-ACC, the input from the EEA can be depicted as follows:

Figure 3.2. **The EEA and ETC-ACC**



First, we will present the current relationships in the EEA's Air and Climate Change (ACC) work area in a 'documentation mode' and the situation as the ETC-ACC is planning for the future in a 'design mode'.

ETC chart flow: current or future (documentation and design) Figure 3.3.



Second, we will show possible data-flows for the driver 'Transport' and, finally, we will introduce four indicators as identified by the ETC-ACC: freshwater stress, change in permafrost, erosion sensitivity and change in growing season.

3.1. Air and climate change

Documentation mode: ShAIR (past situation)
Air pollution and climate change are among the most prominent and overarching environmental issues in Europe, if not globally. The analysis of these themes requires insight into past and current trends, and future scenarios for emissions caused by societal changes (population, energy, transport etc.) and the resulting impacts i.e. large-scale and local air pollution such as from acidification and smog, as well as climate change (e.g. changes in temperature, rainfall, sea-levels, vegetation patterns). The environmental issues of air and climate change can be analysed in terms of emissions and resulting air pollution and human health conditions, and large-scale air pollution, regional and global climate and ecosystems health.

A large number of institutes is involved in the gathering and manipulation of information, depending on each other's input. In this way air and climate change lends itself well to be used as an example for data-flow analysis.

Figure 3.4 shows the current relationships within the EEA Air and Climate Change working area, including institutes, and their inputs and outputs.

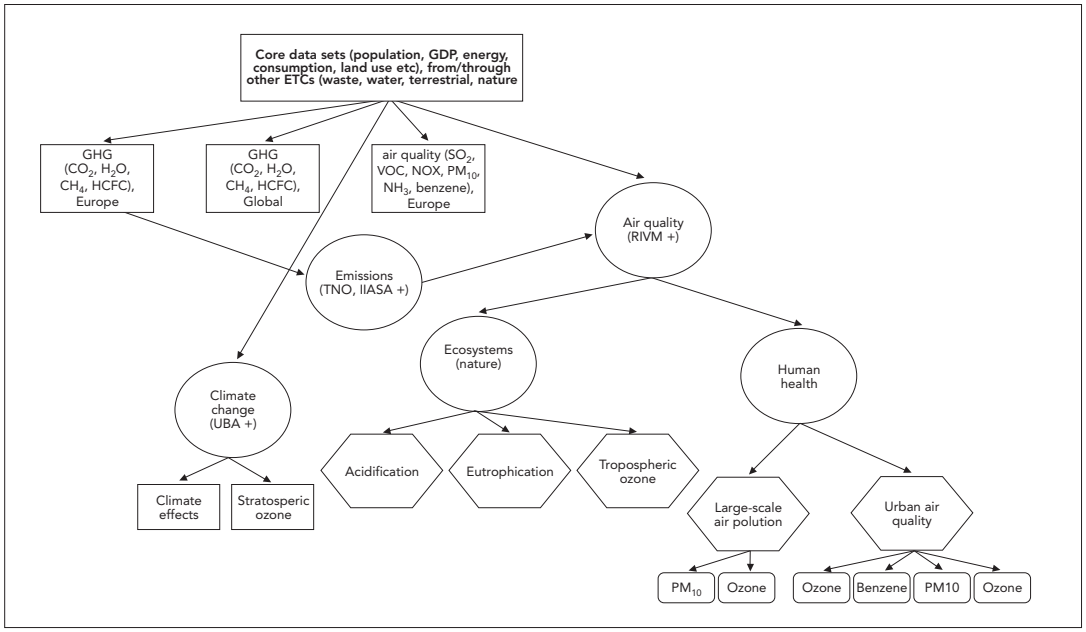
ShAIR background
The EEA initiated the so-called ShAIR study (EEA, 2001a) to evaluate and appraise its past experience in environmental projections underpinning the report 'Environment in the European Union at the turn of the century', (EEA, 1999). This should consolidate the experience gained and help to outline a long-term strategy for integrated assessment and prospective analysis. The ShAIR study, comprising an update of the shared analysis energy scenario underlying the above report for AIR-related issues, focuses primarily on air quality and climate-change related issues, with the following main objectives:

- to test and evaluate the integrated assessment approach to air pollution and greenhouse gases;
- to undertake sensitivity/uncertainty analysis of the baseline scenario used in the EU98 report;
- to further develop expertise, contacts and interrelationships among parties involved;
- to identify relevant indicators, particularly for prospective analysis and policy evaluation;
- to improve/develop accessible methodologies, information flows and tools for integrated assessment;
- to appraise, evaluate and further develop integrated assessment methodology.

The main effort in the project was learning, using and improving the integrated assessment methods and tools, and producing an updated projection on air pollution and greenhouse gases based on the shared analysis scenario.

The ShAIR study made use of experiences gained in recent scenario studies in the context of policy processes in the EU. The initial economic and energy scenario was derived from the shared analysis scenario, which is a 'baseline' energy scenario assuming existing agreed and adopted policies and measures. Various scenario assumptions have been updated, and the resulting scenario version, with a time horizon extended to 2020, is referred to as the ShAIR scenario. Based on these underlying trends, integrated projections have been made for emissions of greenhouse gases, long-range transboundary air pollution and urban air quality. The ShAIR study showed improvements of some of the elements in the model network to be necessary.

Figure 3.4. **Overview of a quantitative scenario evaluation for air pollution and climate change; the current situation is based on ShAIR reports (2)**

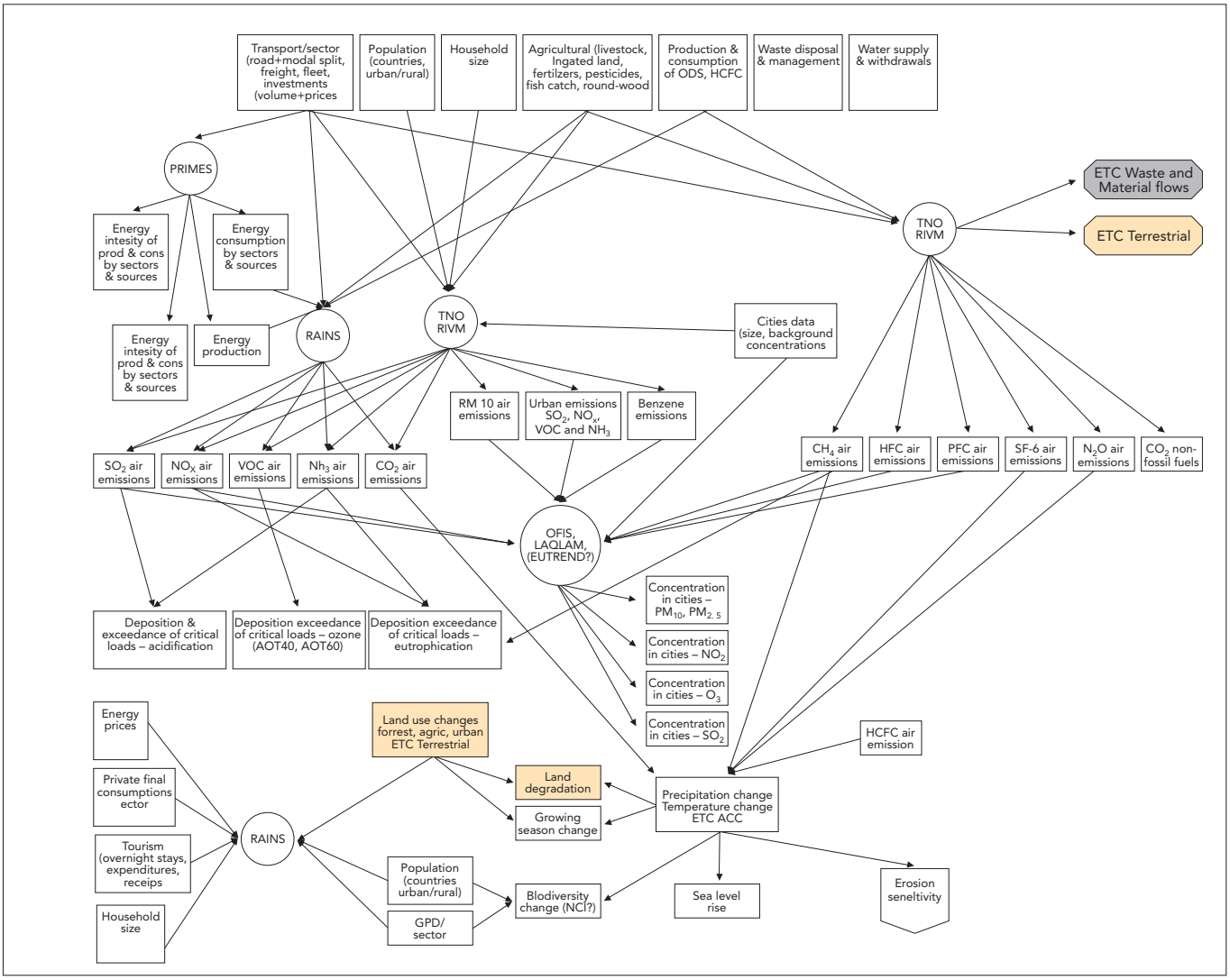


Shown are the participating organisations and the data-flows between them, broadly defined by topic as an example of the documentation mode of data-flow analysis. No more than approximately 20 objects are shown. This overview shows, for example, that the air and the climate components are linked by joint scenario assumptions and joint emission estimates.

The more detailed overview (Figure 3.5) looks inside the working areas of the various partners. It specifies in some detail the data exchanged and the data manipulations. Complete databases are available for most of the data; data can be viewed by clicking on the relevant shapes in the charts. Meta information on models can also be provided in the same way. It should be emphasised that this amount of detail is suitable rather for managing components of a broad-based assessment like the SoEOR 2004 and the underlying data arrangements, than for the full assessment.

(2) The flowcharts in Figures 3.4, 3.5 and 3.6 do not fully match the legend and auto shapes as designed in the IEA- explorer. They are identical with the flowcharts in EEA (2001a) making them recognisable for people who are familiar with the ShAIR network. The charts drafted for the indicators, however (see Figures 3. 7 to 3.12), do indeed follow the legend and auto shapes as normally used in the IEA-explorer.

Details of quantitative scenario evaluation for air pollution and climate change; current situation is based on EEA (2001b) Figure 3.5.



This is an example of the level of detail that has not proven useful for planning and managing full, broad-based integrated assessments. However, it may satisfy needs of management and background documentation once the assessment has been compiled and visualised on a less detailed level. Note that it is difficult to obtain an overview of this scheme. It nevertheless shows that emission estimates for carbon dioxide and other greenhouse gases have come from different organisations.

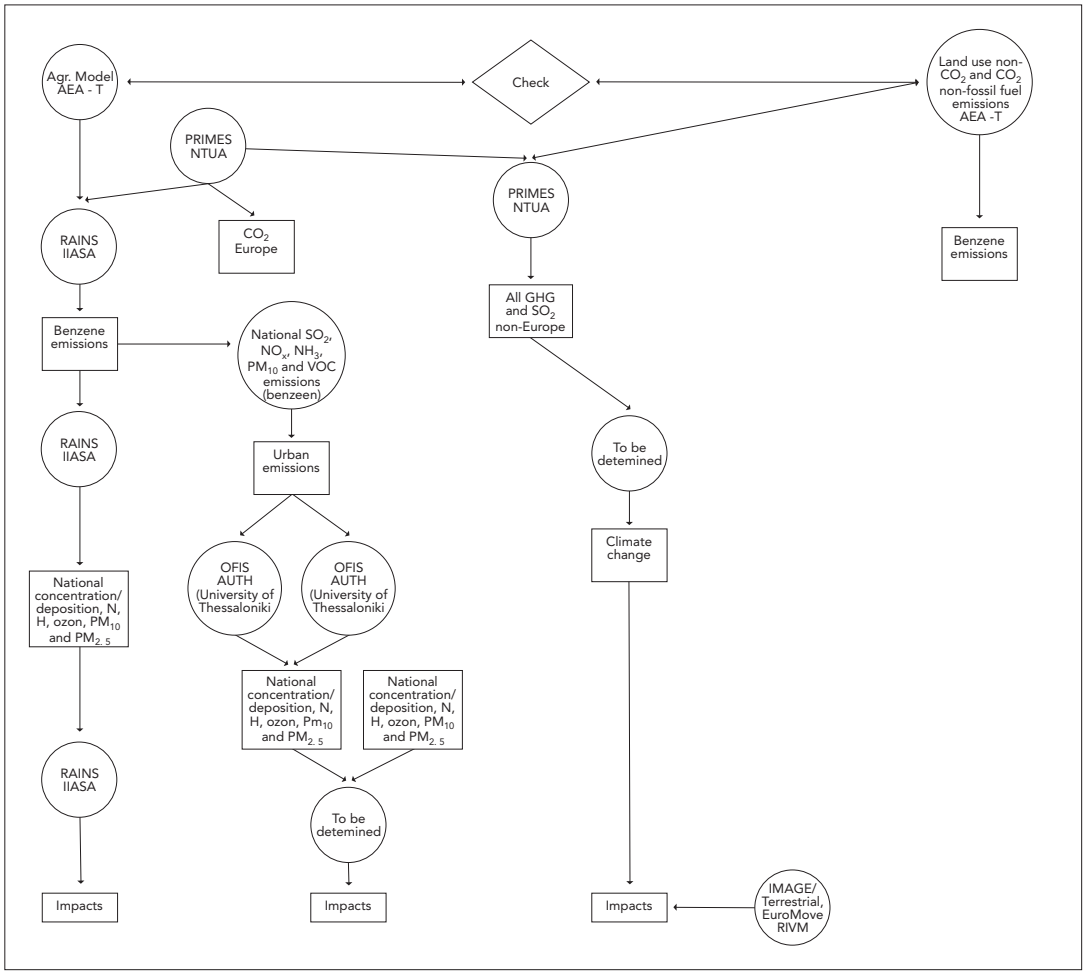
Design mode: future assessments

Building further on work done previously, as well as on terms of reference for the ETC/ACC, the issues of air and climate change have tentatively been expressed in the following series of outputs:

- regional and urban anthropogenic air emissions of GHG (CO_2, CH_4, N_2O, HFC, PFC, SF_6);
- exceedance of critical loads of acidification compounds (SO_2, NO_2, NH_3);
- exposure to tropospheric ozone produced by precursor emissions NO_x, CO, NMVOC;
- emissions and exposure to Hg and other heavy metals (Pb, Cd, Ni, As);
- emissions and exposure to POPs (PAHs, dioxins/furans, HCBs);
- exposure to UV caused by emissions that cause ozone depletion (HCFCs, methylbromide);
- human health exposure: particulate matter (PM_{10}, $PM_{2.5}$) and benzene, NO_2.

Based on this list of required outputs, the aggregated data-flows between the institutes can be depicted as follows:

Figure 3.6. **Tentative overview of future data-flows, European Topic Centre on Air and Climate Change**



This is an example of data-flow analysis in the 'design mode': restricted detail and focus on who supplies input to whom. Apart from the labels 'to be determined' it is apparent from this chart that the network lacks a common scenario driving its calculations (*Source*: ETC-ACC)

The trends and scenarios for the driving forces are to originate from outside the Topic centres, as organised by EEA; the same goes for information on the environmental policies to be analysed by these Centres. Each element in the diagram needs to link up to appropriate descriptive information such as datasheets, fact sheets and model descriptions. For example, the PM10 box would be linked to a fact sheet giving information such as the country emissions for several scenarios, policy targets in the EU, descriptions of the model used and the input data used. The standard format of the fact sheet has recently been established by EEA.

Issues

As an example of issues that can be identified with this level of data-flow analysis, the lack of a common scenario can be mentioned. This is obvious from the chart. Past and recent data-flow analysis exercises have highlighted a clear need for developing generic, harmonised and multi-purpose socioeconomic scenarios, and support data sets (e.g. population density, cities — size and locations). Thus the issue is not new, but the chart helps to make it specific in terms of what parts of the ETC organisation need to be furnished with a common EEA scenario. Furthermore, a comprehensive overview of the relevant environmental policies and targets needs to be at hand.

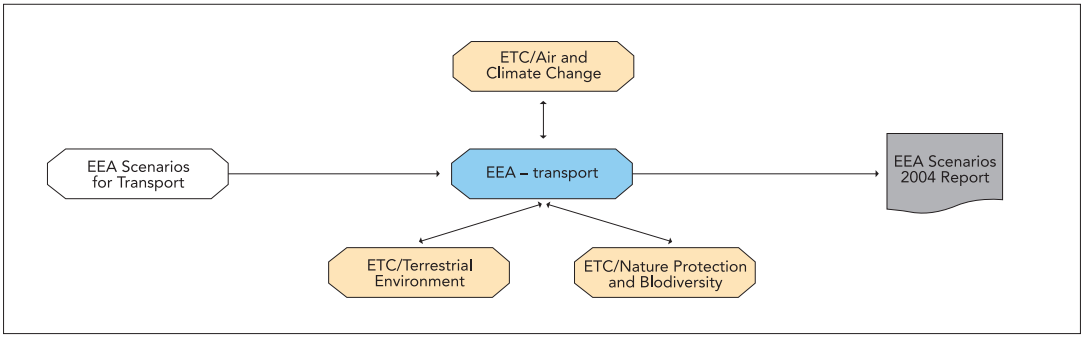
3.2. Transport

Description
The transport case here constitutes an example of the 'design mode' of data-flow analysis. However, it reaches a level of detail which — while necessary to understand what will be required — is pertinent to the type of planning within a specific ETC rather than to the management of the SoEOR 2004 as a whole. However, at the time of writing it was not clear where in the EEA organisation work on sectoral scenarios would be placed.

Transport is a well-documented driving force associated with a number of environmental issues, including air and climate change. Transport has been widely explored by the EEA in the transport and environment reporting mechanism, 2000 and 2001 reports (EEA, 2000; EEA, 2001b). The indicators in these reports are based on the DPSIR assessment framework; some indicators in the TERM 2001 report include projections for 2010 and 2030. The transport scenarios to be included in the SoEOR 2004 have not yet been decided; however, transport has been included in several scenario reports produced by the ETC-ACC on air emissions, air quality and impacts of air pollution (EEA, 2001a). Another useful publication is the OECD synthesis report on environmentally sustainable transport (EST), which includes scenarios for 'business as usual' and environmentally sustainable transport (OECD, 2000).

To maintain consistency with EEA work, these reports and the TERM 2001 report were used as a starting point when assessing data-flows associated with transport as a sectoral driving force. The scheme below outlines the possible data-flows at the highest level i.e. the ETC and EEA level, possibly required for the production of integrated assessments of transport as a driving force. This scheme illustrates the type of flowchart drawn for transport scenarios (and should therefore be viewed as being drawn in the 'design mode'), rather than the actual, not yet decided, data flows that will be in place for the production of the SoEOR 2004. The flow chart below clearly shows that in the analysis of the data flows needed to determine a single indicator, like transport, many ETCs other than transport can be involved.

Figure 3.7. **Chart transport overview**



A review of the reports mentioned earlier highlighted the main parameters of transport to be:

- economic activity — freight and passenger transport (in passenger-km/tonne-km);
- transport price — fuel price (diesel and petrol), public transport price;
- number of vehicles — freight fleet and passenger cars;
- GDP;
- disposable income;
- development in transport infrastructure.

These parameters can give rise to, amongst other things, an increase in energy consumption, emissions of greenhouse gases and air pollutants, noise, waste generation and changes in land use. This can eventually lead to impacts on climate change, air pollution, acidification, biodiversity and human health conditions.

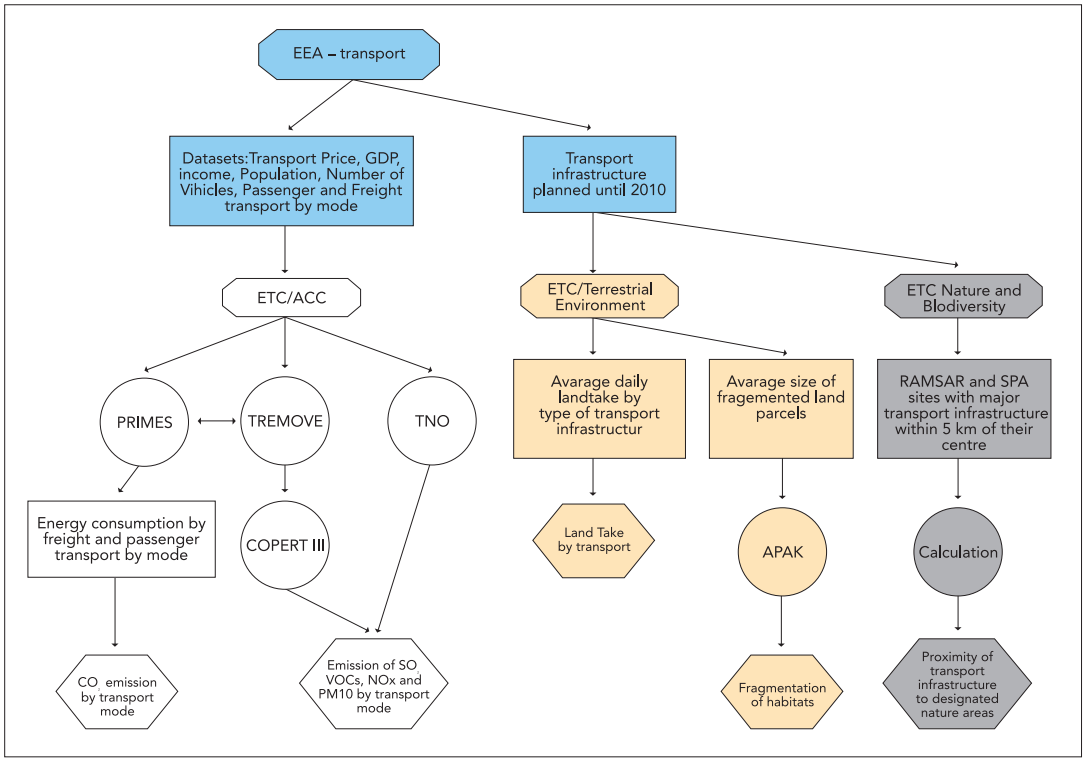
Following previous work in the EEA report on Environment in the European Union at the turn of the century, TERM 2001, scenario reports from ETC-ACC and the OECD EST

synthesis report, some of the indicators that can be used to express the pressures and impacts resulting from transport as a driving force are:

- emissions of CO_2 by transport mode;
- emissions of acidification compounds (NO_x, SO_2 and NH_3) by transport mode;
- emission of PM10 by transport mode;
- land take by transport infrastructure;
- fragmentation of habitats by transport infrastructure;
- proximity of transport infrastructure to designated nature areas.

The diagram below shows inter-links in the data-flow required for these indicators at an aggregate level.

Figure 3.8. **Chart transport detail**



Socioeconomic and sectoral trends, outlooks and scenarios will be collected outside the Topic Centres, co-ordinated by the EEA. EEA transport experts will collect transport data. ETC-ACC could collect and manipulate air emissions from transport. ETC Terrestrial Environment (ETC TE) could collect and manipulate data for land take and fragmentation of habitat. ETC Nature Protection and Biodiversity could calculate proximity of transport infrastructure to designated nature areas. This detail of data chart outlines the main data-flow between different groups. Further information on the manipulations of data, models used and the data itself will be linked to the specific boxes in this chart. This would include links to the EEA fact sheets, a standardised way of recording and presenting background information, and data for all indicators produced by the EEA.

Issues for further consideration

Transport was selected as a driving force prototype since it is a well-established and researched source of environmental problems. However, at present, there is little involvement of ETCs in the production of the transport indicators and few scenarios for transport as a driving force of environmental problems. Using transport as a prototype for the DAFIA II project has highlighted the possible linkages that may exist for scenario indicators to be produced by the EEA.

Data from a number of different sources and collected by different staff members are likely to be required. Therefore it is important to show clearly the linkages between ETCs and the

EEA, so those working in different organisations can identify their own and other responsibilities in the environmental reporting process. It is also important that an Internet/intranet facility is available so the data-flow charts and background information i.e. fact sheets and model descriptions, are readily available for all those involved in the process, but who may be working remotely.

3.3 Four indicators

The selection of the elaborated indicators for climate change was based on a longer list resulting from a survey by the ETC-ACC on the priority indicators. The four indicators presented here are especially interesting as illustrations, because these indicators are of relevance for all European regions and the data-flows involved concern several ETCs. The indicators presented include freshwater stress, change in permafrost, erosion sensitivity and change in growing season.

The flow charts are made in a 'design mode'. However, though the flow charts have been drawn in consultation with the ETC-ACC and the ETC-WTR, and hence should make sense in their eyes, they do not represent actual established ETC plans. They are hypothetical examples.

The flow charts come in two layers. The first chart shows the organisations involved and aggregated data flows between them. The second aims at sufficient detail to facilitate a discussion in terms of substance.

Water stress
(hypothetical flow charts)

Water stress overview flow chart — Figure 3.9a.

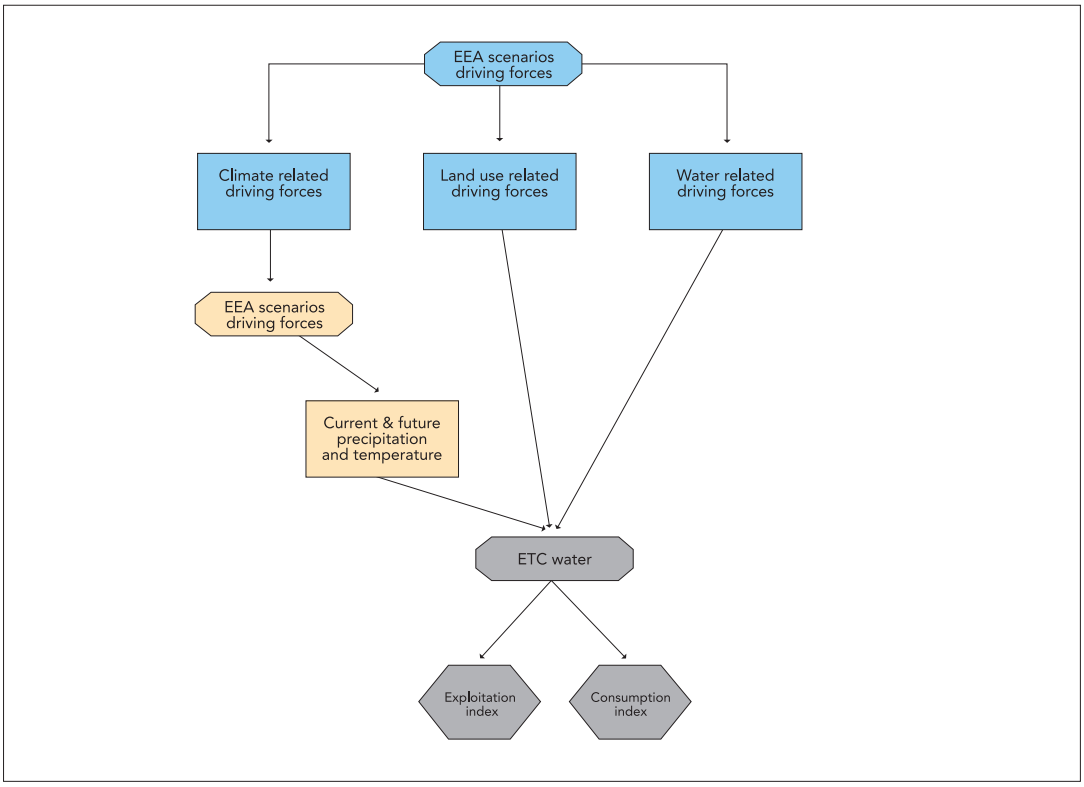
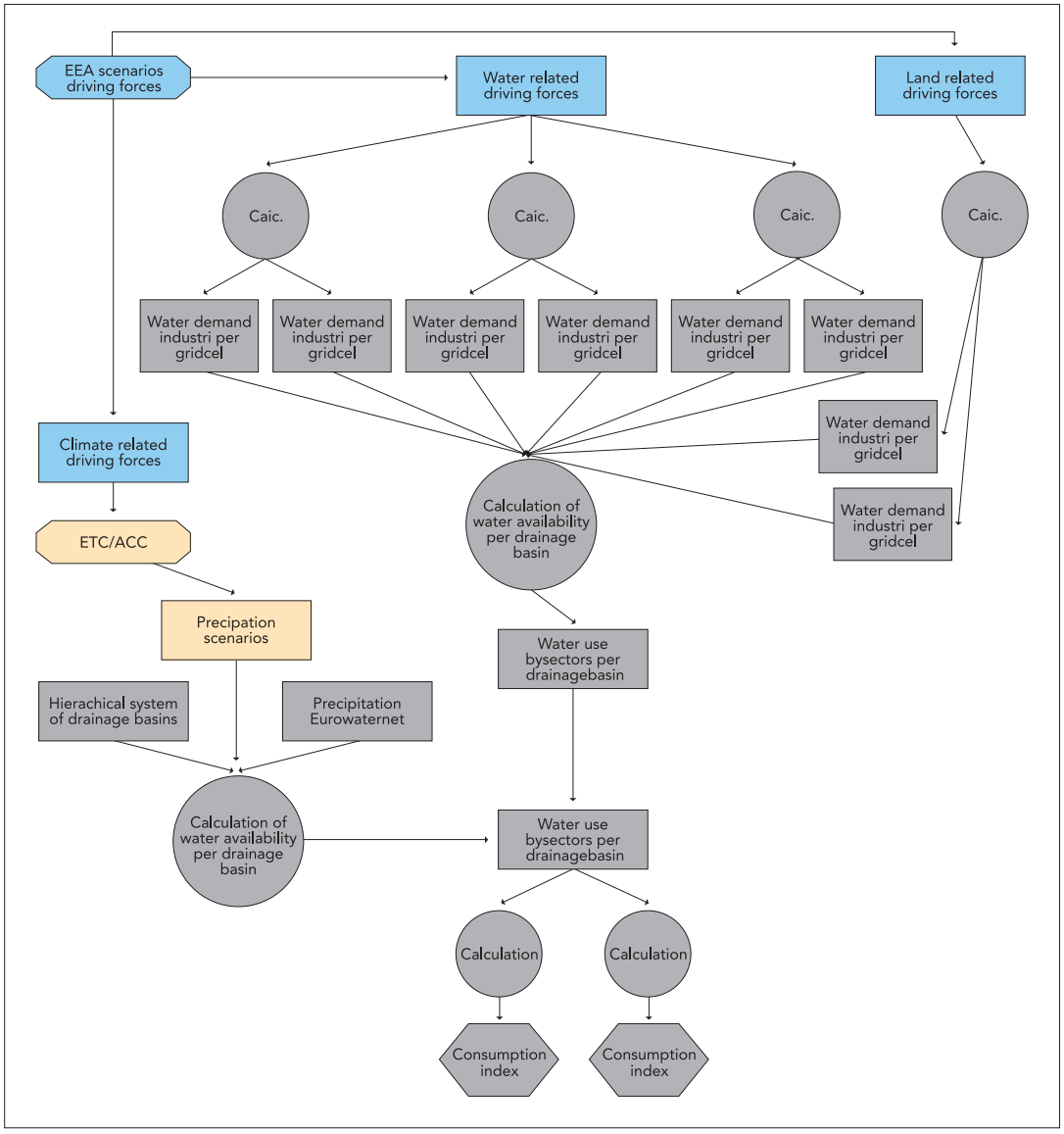


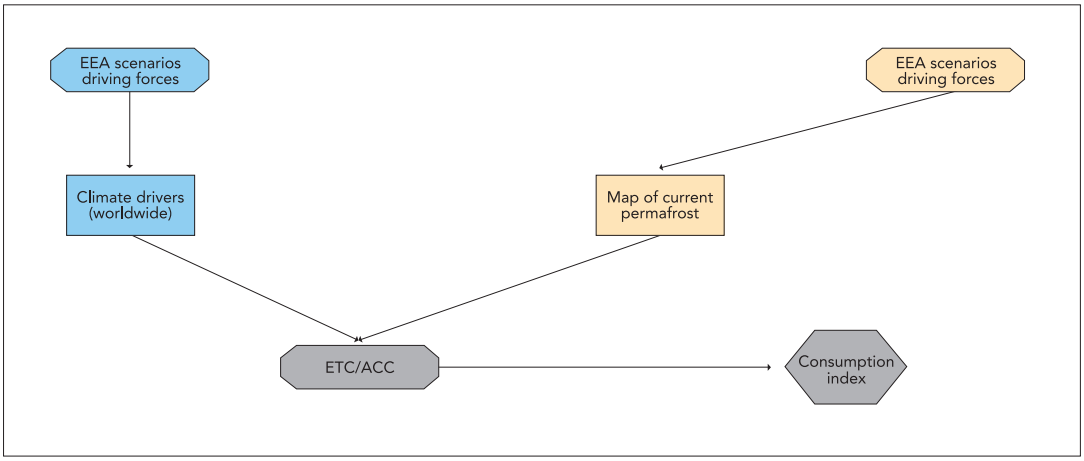
Figure 3.9b. **Water stress detail flow chart**



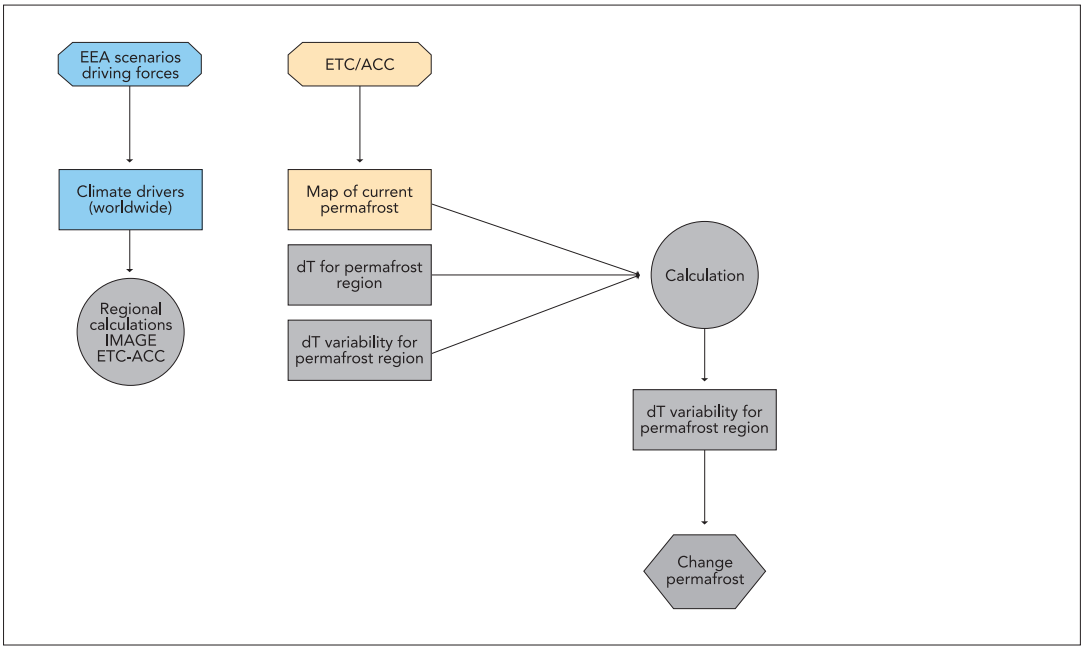
Water stress indicates the mismatch between freshwater availability and freshwater demand (Alcamo *et al.*, 2000). For the development and documentation of this indicator, the ETC-WTR is the most involved unit. The EEA provides input with scenarios on drivers related to climate, water and land use. The ETC-ACC provides information on future precipitation and temperature. The ETC-WTR organises the information on water demand. What is not shown in this picture, is the fact that projections of irrigated agriculture (how much and where) would assumedly be produced by the ETC-TE. Therefore, the ETC-WTR will have to check its own data on future water demands related to land use, with the data on future land use from the ETC-TE. This in itself is interesting from an organisational and consistency point of view. It illustrates the fact that different sources of data exist which have to be checked with each other.

Change in permafrost
(Hypothetical flow charts)

Change in permafrost overview flow chart Figure 3.10a.



Change in permafrost detail flow chart Figure 3.10b.



Increase in temperature can lead to shrinkage in permafrost. Shrinkage of permafrost leads to extra methane and carbon dioxide emissions and could cause damage to infrastructure. In this example, for permafrost most calculations are supposed to be done by the ETC-ACC using information on climate driving forces provided by the EEA and information on current permafrost from EEA Terrestrial Environment.

Changes in growing season
(Hypothetical flow charts)

Figure 3.11a. **Change in growing season overview flowchart**

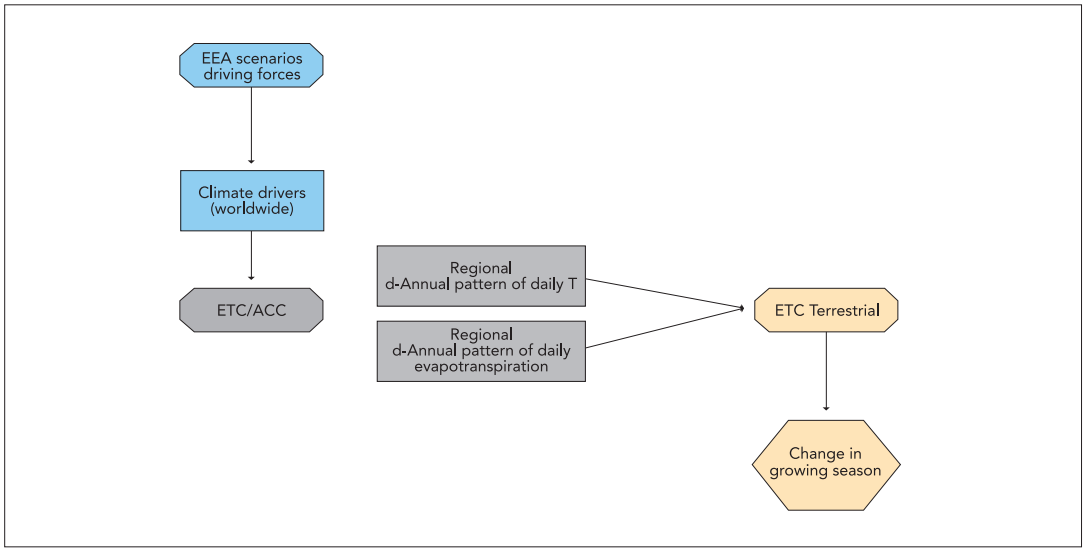
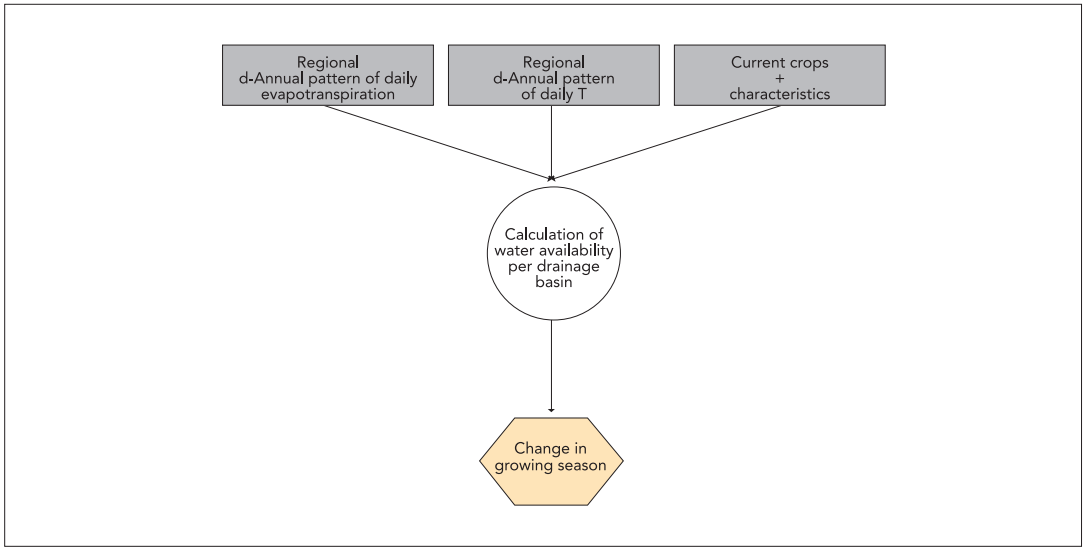


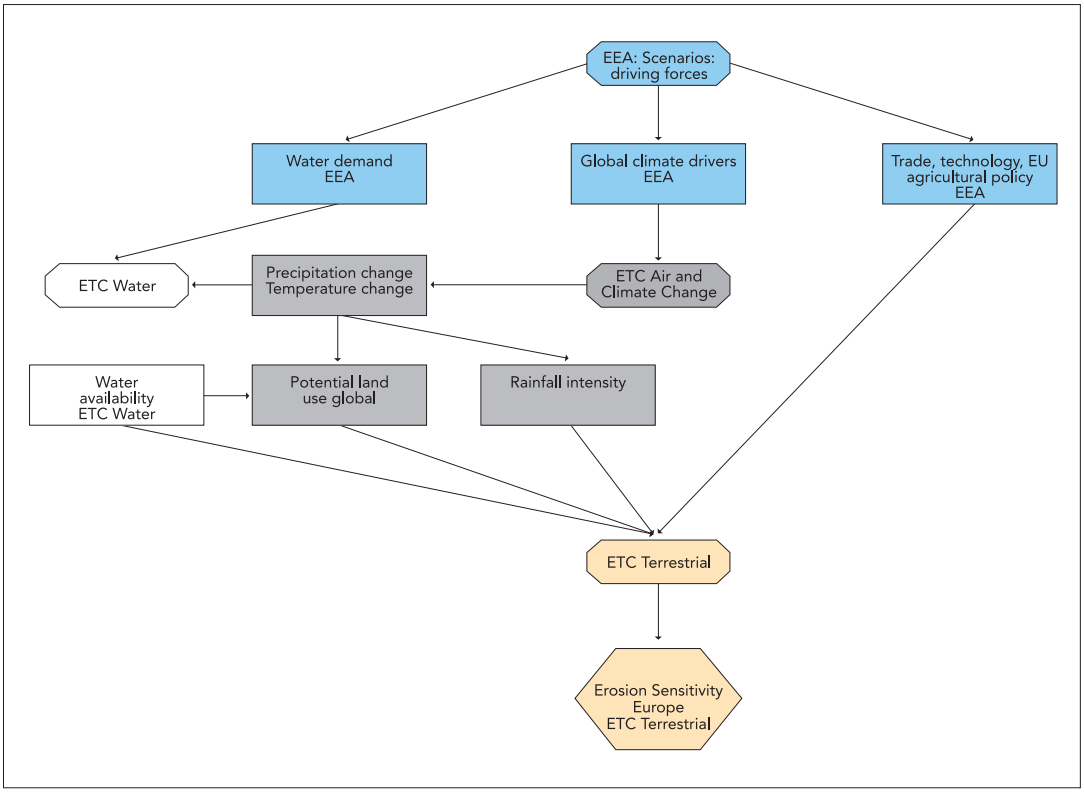
Figure 3.11b. **Change in growing season detail flowchart**



Changes in growing season cause a shift in stability of ecosystems, and change in crop growth (Leemans and Hootsmans, 1998). In this example, for changes in growing season (both for crops and natural vegetation), the ETC-ACC and ETC Terrestrial Environment are involved. The ETC-ACC gets information from the EEA on climate drivers and subsequently provides input for the calculations on changes in the growing season by the ETC-TE.

Erosion sensitivity
(hypothetical flowcharts)

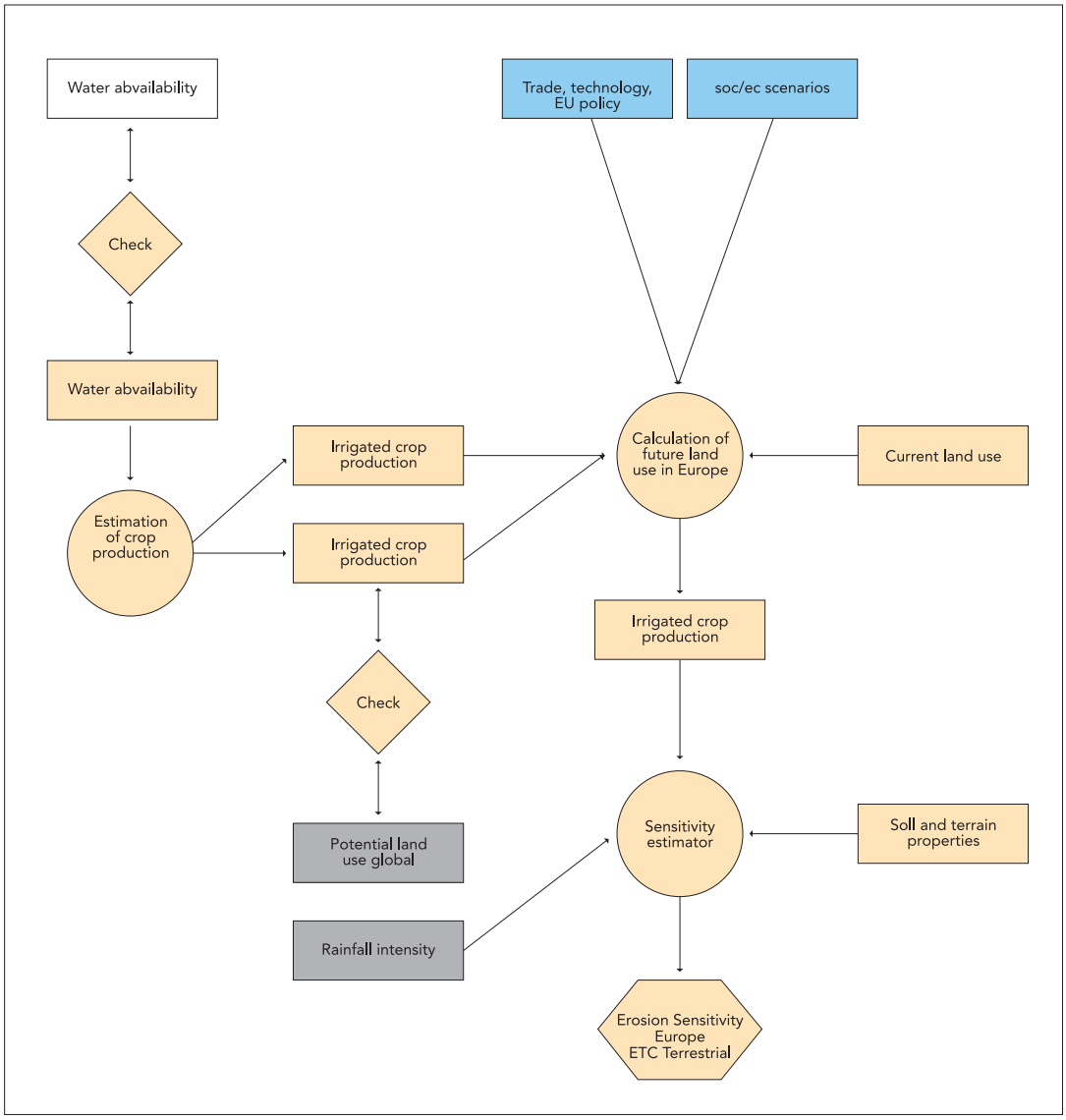
Erosion sensitivity overview flowchart Figure 3.12a.



Changes in water availability and land use can increase erosion sensitivity of land. Erosion has consequences for soil quality and crop production (Hootsmans et al., 2001).The development and calculation of the indicator Erosion Sensitivity is quite a complicated procedure involving the ETC-ACC, TE and WTR. The EEA provides the information on climate drivers and drivers related to water, which are used by the ETC-ACC and the ETC-WTR for the calculation of potential land use, rainfall intensity and water availability. At the same time the ETC-WTR and the ETC-ACC need each other's input for the calculation of those very data. The outcomes are used by the ETC-TE to calculate the final erosion sensitivity, also using information on EU landuse policies and trade from the EEA. At several stages the ETC-TE has will have to check its figures with information from other sources.

For example, though the ETC-TE will be able to determine future land use in Europe from European land use policies and current landuse maps, it has to check those maps against the global potential landuse data from the ETC-ACC. It also has to check water demand with water availability data from the ETC-WTR.

Figure 3.12b. **Erosion sensitivity detail flow chart**



4. Conclusions and recommendations

Approach

- The use of data-flow charting as a management tool has the potential to improve communication among the EEA and its partners and in the final products (reports, etc.), if only by improving clarity, keeping track of data-flows and better documentation of the data sets, models and scenarios used.

- Data-flow charting could also prove useful in highlighting missing data and information elements, and thus also help in formulating future data collection needs in Europe, in particular, when extending the assessment and related scenario work into central and eastern Europe.

- Connecting existing information and meta-information systems to flow charts rather than duplicating them within the charting system would increase the user-friendliness of the tool and avoid increasing the administrative burden.

Modes of data-flow analysis

- In the EEA context, data-flow analysis has potentially two roles: 'design mode' and 'documentation mode'.

- The design mode is a planning and managing tool and can play as such an important role in making practical and relevant recommendations, addressing the interdependencies between ETCs, the need for consistency in sectoral projections and the requirements for scenario information concerning non-EU countries.

- The documentation mode can serve as a managing tool for monitoring and tracking with the aim of improving reporting process efficiency and transparency.

- The design mode requires thinking in terms of transfer of data sets from one responsible unit to another, i.e. which ETC delivers what information to which other ETCs? Detailed planning on the level of information flows within the ETCs themselves is not needed in this stage.

- The design mode requires thinking in terms of supporting discussion in working groups at various stages in the assessment process.

Software tool

- Tools with the look, feel and language geared to an IT audience should be avoided.

- After a tentative scan of the market, it appears that the relatively simple, Microsoft-based and dedicated software tool IEA-explorer, developed and in use at RIVM comes close to the requirements of the EEA by means of the DAFIA II study. For the EEA, this tool could be used under the name DAFIA.

- It is recommended to investigate in detail the way the selected tool can be operated via the Internet in conjunction with ReportNet, and its implications for development of the tool in the near future.

- It is recommended to progressively introduce the schematisation techniques (data-flow charting) — instead of the other software components — of the EEA version of the IEA-explorer (DAFIA) into the activities of the ETCs and EEA task managers.

- To further improve the overall reporting process, it could be useful to explore possibilities to connect 'data-flow charting' with other system parts, such as project planning tools, so as to be better informed on who should do what, when etc.

Lessons from the demonstration cases

- The data-flow charting exercises on two issues i.e. air and climate change, and transport, revealed that the level of clarity on indicators, scenario assumptions and other elements of the reporting process is still rather low. The exploration exercise of the reporting process through data-flow charting is in itself a very useful learning experience; this could be practised within the EEA network through workshops for the major environmental topics to be addressed.

- Examples in this report suggest that the tool and methodology should be excludeable to all environmental issues and eventually to the overall integration for the next EEA environmental state and outlook report.

- Even the limited demonstration cases indicated clearly that quite a few ETCs can be involved in the data-flow for one given indicator. The cases have not yet highlighted two other complications that can be traced by data-flow charting, viz. (i) scenario work requires many other sources of data than existing within the ETC network; (ii) central and eastern Europe are often not covered in current scenarios.

Possible application

The DAFIA schematisation technique would be very valuable in:

— design mode:

- preparing the scenario base of the 2004/2005 report

- preparing the indicator proposals of the new ETCs, including inter-ETC connections as demonstrated in this report for four climate impact indicators;

— documentation mode:

- documenting the data flow for the production of sector-oriented indicator reports of the agency, in particular TERM (indicators on transport and environment integration in the EU).

References

Alcamo, J., Henrichs, T., Rösch, T., (2000) *World water in 2050. Global modelling and scenario analysis for the World Commission on Water for the 21st century.* Kassel World Water Series. Report No 2.University of Kassel. Centre for Environmental Systems research.

Bakkes, J. A., Nijland, H. A., van Overveld, M. J. L. C., Schaap, A. J. (1991a), *Naslagwerk analyse informatie-uitwisseling milieuverkenning (AIM).* Bilthoven, RIVM Report No 481502003.

Bakkes, J. A., Nijland, H. A., van Overveld, M. J. L. C., Schaap, A. J. (1991b), *De verkenning verkend. Conclusies en aanbevelingen uit de analyse van de informatie-uitwisseling voor de Nationale Milieuverkenning 2 (AIM 1991).* Bithoven, RIVM Report No 481502004.

EEA (2001a), *The ShAIR scenario — Towards air and climate change outlooks integrated assessment methodologies and tools applied to air pollution and greenhouse gases'*, EEA Topic report 12/2001 Copenhagen.

Eionet (2000), *Strategic plan for the Eionet IT development*, Eionet newsletter No 6, February 2000.

EEA (2000), *Transport and environment reporting mechanism (TERM) 2000 — Are we moving in the right direction?,* Copenhagen, EEA.

EEA (2001b), *TERM 2001 — Indicators tracking transport and environment integration in the EU,* Environmental issue report No 23, Copenhagen, EEA.

EEA (1999), *Environment in the European Union at the turn of the century,* Copenhagen, EEA.

Hootsmans, R. M., Bouwman, A. F., Leemans, R., and Kreileman, G. J. J. (2001), *Modelling land degradation in IMAGE 2,* RIVM Report 481508009, Bilthoven

Leemans, R., and Hootsmans, R. (1998), *Ecosystem vulnerability and climate protection goals,* RIVM report No 481508004, Bilthoven

OECD (2000), *Synthesis report of the OECD project on environmentally sustainable transport (EST),* — available at http://www.oecd.org/env/ccst/est/curract/vienna2000/EST-Synthesis-Report-Part1.pdf

Post, W., and Wieringa, K., (1997), *DAFIA-1: Data flow analysis for integrated assessments – final report,* EEA/JRC Technical Note No I.97.148

RIVM (1989), *Concern for tomorrow. A national environmental survey 1985–2010*, Bilthoven, RIVM.

RIVM (1991), *National Environmental Outlook 2 1990–2010*. Bilthoven, RIVM

Software

Rational Rose (2001)	Rational Software, www.rational.com
System Architect (2001)	Popkin Software, www.popkin.com
SDW (2001)	Systems development workbench, developed by Cap Gemini, now in maintenance by Bwise, www.bwise.com
Igrafx Flowcharter (2001)	(Formerly ABC-flowchart) from Micrografx, www.micrografx.com.