IMPACTS

An Information Tool for Citizens to Assess Impacts of Climate Change from a Regional Perspective

CHRISTOPH SCHLUMPF[1], CLAUDIA PAHL-WOSTL[1⋆], ANDREAS SCHÖNBORN[2], CARLO C. JAEGER[3] and DIETER IMBODEN[4]

[1]*Swiss Federal Institute of Environmental Science and Technology (EAWAG), Überlandstrasse 133, 8606 Dübendorf, Switzerland*
[2]*Armadillo Webworks, Bruchstrasse 69, CH-6003 Luzern, Switzerland*
[3]*Potsdam Institute for Climate Impact Research, Telegrafenberg, 14473 Potsdam, Germany*
[4]*Swiss Federal Institute of Technology, Zürich, Voltastrasse 65 – VOD, 8092 Zürich, Switzerland*

Abstract. Participatory Integrated Assessement (IA) methods complement analytical methods like IA-modeling in their explicit inclusion of stakeholders and decision-makers in the assessment. Integrated Assessment is perceived as a process of social learning involving scientists, stakeholders, policymakers and the society at large. We introduce a new approach to provide expert knowledge for participatory integrated assessments of regional climate change: 'Interactive Citizen's Information Tools' (ICITs). ICITs provide citizens with expert knowledge about causes of climate change, potential impacts, and policy options to address anthropogenic climate change. In this paper we discuss the development and application of IMPACTS in IA-focus groups in Switzerland. IMPACTS is based on user-friendly hypermedia technologies and allows citizens to get informed on a broad range of potential climate change impacts – with an emphasis on prevailing uncertainties. IA-focus groups are deliberative group discussions that make use of computer tools to support the discussion and assessment. The goal of IA-focus groups is to elicit how informed citizens judge the risks of anthropogenic climate change. Experiences with IMPACTS showed that the combination of focus groups with ICITs is a feasible and promising approach for a participatory IA of regional climate change, in particular, and of complex environmental issues, in general.

1. Introduction

Collaboration of scientists with decision-makers to address complex problems in the field of environmental policy has a long history (Jasanoff and Wynne, 1998). Anthropogenic climate change is a prominent recent phenomenon where decision-makers and scientists are working together to make integrated assessments. The complexity of climate change as a scientific research field and as a societal decision problem led to the development of 'Integrated Assessment' (IA) as a specific branch of research. IA is devoted to develop methods to study complex societal decision problems with large uncertainties and to support decision-makers in their assessment. IA as a kind of a 'transdiscipline' is still in development and many definitions circulate (Jaeger et al., 1997; Parson, 1996; Rotmans and van Asselt,

⋆ Corresponding author.

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1996; Weyant et al., 1996). The definition of Rotmans and Dowlatabadi (1998) emphasizes the twofold task of 'integrating' knowledge from different disciplines and 'assessing' knowledge for decision making:

> 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 interactions of a problem can be evaluated from a synoptic perspective with two characteristics: (i) it should have added value compared to disciplinary assessments; and (ii) it should provide useful information to decision makers.

Morgan and Dowlatabadi (1996) summarize insights from a decade of integrated assessment on global climate change. In particular they emphasize '. . . that many decisions will be made by the individual choices of millions of organizations and citizens, and these will be driven by local interests and conditions. The climate decision makers are diffuse groups spread all over the globe who will make a number of sequential climate-related decisions that are primarily driven by local *non-climate* considerations'. They conclude that the biggest challenges for an integrated assessment of climate change are philosophical and methodological rather than adding further knowledge. They pose the questions: 'How should one deal with both manageable and extreme uncertainties? How should one deal with the adaptive process of a wide range of values and expectations which shape decision making and which are not accessible by a view of decision making based on a single rational utility maximizing decision-maker?'

One approach to improve the understanding of local decision making is through the explicit participation of decision-makers and stakeholders in the integrated assessment. The emerging methods of Participatory Integrated Assessment (PIA) utilize this approach (Dürrenberger et al., 1997). PIA complements existing methods by assessing a broader context of societal decision making. Human participants are interacting with one another and with expert knowledge in a structured and decision oriented setting. Policy exercises, scenario exercises, and simulation-gaming are examples of such methods (Parson, 1997; Rotmans, 1998).

One crucial part of PIA is to integrate scientific knowledge (facts and uncertainties) in participatory methods to improve the overall assessment. Current IA-models and scientific reports are produced for scientists or international policy processes and not for local decision-makers in participatory settings.

We introduce in this paper a new approach to integrate scientific knowledge in participatory methods: IA-focus groups with citizens informed by 'Interactive Citizens' Information Tools' (ICITs). In this approach, decision making is studied as a process of social learning among citizens, scientific experts and policymakers. ICITs have a twofold role in this IA approach, a role that is both, supply and demand driven. ICITs are designed to *supply* scientific information to a broader audience. But they are also built in close collaboration with sociologists and tested in focus groups to comply with the *demands* of citizens for information to support their assessment. The method has been developed within the integrated transdisciplinary research project CLEAR* (Cebon et al., 1998). CLEAR consists of over a dozen disciplinary projects involving natural and social scientists that study climate change in the Alpine region.

ICITs are computer-based interactive information tools for citizens. Their purpose is to make decision oriented expert knowledge on complex problems accessible and utilizable for citizens. ICITs can be composed of a combination of deliberative expert judgements and formal simulation models in the form of texts, graphs, images, animations, interactive simulation models and calculation tools. They provide structured, interactive and descriptive access to this expert knowledge. The graphical user interface of ICITs is targeted towards citizens with no expertise in using computers.

In contrast to IA-models, ICITs are not used to make overall assessments of climate change in a formal framework based on simulation models. Therefore, ICITs can more easily be complemented with qualitative information and can illustrate conceptual uncertainties. They convey qualitative, quantitative and conceptual expert knowledge that is relevant for citizens in their assessment of the problem at hand. Table I highlights the main differences between conventional IA-models and ICITs. IA-models are to a large extent limited to information that can be represented in simulation models. Experiences with IA-models in IA focus groups in the ULYSSES project (for example the TARGETS CD-ROM and ICAM) show that despite considerable efforts to adapt them for IA-focus groups, most models are not sufficiently user friendly and transparent for being accessed by citizens (Dahinden et al., 1999). As most IA models were never intended for use by citizens/lay people, this result is not that surprising. Nevertheless, this observation indicates that the current IA models are not the best tools to inform citizens about the climate change issue.

ICITs provide easy to handle user-interfaces for lay persons. They are self-explanatory to a large extent. We rested heavily upon the concepts of hypermedia systems user interfaces (Balsubramani and Turoff, 1995) and especially the World Wide Web to build first ICITs for IA-focus groups. The term 'Hypermedia' stands for an information system that embeds information in different media (text, images, animations, movies, sound, etc.) and that allows non-linear and flexible navigation. Information is linked in a network structure with hyperlinks to navigate through them.

'IA-focus groups' is a participatory method developed within the two research projects CLEAR and ULYSSES** (Dürrenberger et al., 1997; Kasemir, 1997). The

* CLEAR (Climate and Environment in Alpine Regions) is an integrated research project of the SPPE (Swiss Priority Program Environment) of the SNF (Swiss National Science Foundation). More information can be found on the project's WWW site (http://CLEAR.eawag.ch).

** ULYSSES – Urban Lifestyles, Sustainability and Integrated Environmental Assessment, financed by DG XII of the European Commission (Fourth Framework Programme – RTD Programme Environment and Climate). More information can be found on the project's WWW site (http://www.zit.tu-darmstadt.de/ulysses/)

aim of these IA-focus groups is to explore how informed citizens assess anthropogenic climate change. We will explain why we focus on citizens as important stakeholders and decision-makers in IA in Section 3.1.

We developed an information platform composed of several ICITs that is specifically targeted towards IA-focus groups with citizens. IMPACTS is the central part of this information platform. It is used to inform citizens about the current scientific knowledge on anthropogenic climate change with an emphasis on regional impacts and their associated uncertainties. What kind of scientific knowledge has to be integrated in such an information tool and how can this information be produced? How should the knowledge be presented to citizens? In this paper we try to explore first suggestions based on our experiences with IMPACTS in IA focus groups in the CLEAR Project.

In Section 2 we discuss the problems of assessing climate change from a regional perspective. Section 3 introduces IA-focus groups with citizens and interactive information tools (ICITs) as our approach to participatory IA. We present the CLEAR Information Platform as a first implementation of ICITs for IA-focus groups.

Section 4 focuses on IMPACTS as the central ICIT used in the CLEAR project. We explain the target and the requirements of IMPACTS in terms of contents, form and functionality. An overview of the structure and main components in IMPACTS is given. Section 5 focuses on the problem of communicating uncertainties and how we accomplished this in IMPACTS.

We present first experiences with IMPACTS in IA-focus groups with citizens in Section 6. We describe the citizens' evaluation of IMPACTS as an information tool and their assessment of regional climate change. Section 7 provides some reflections and lessons learned from our experience as well as some thoughts on the usefulness of ICITs for participatory IA methods.

2. Integrated Assessment of Regional Climate Change

In the context of anthropogenic climate change an integrated assessment comprises the whole cause effect chain from socio-economic pressures leading to an increase in atmospheric greenhouse gas concentrations to the resulting climate change with its impacts on the natural environment, on the economic system and on our society at large. The PSIR (pressure, state, impact, and response) framework (Rotmans et al., 1994) provides a good illustration of this cause-effect chain with its feedback loops through adaptation, geo-engineering and mitigation policies.

Differences in values and objectives prevent collectives of decision-makers from using the same selection criterion for decision alternatives (Jaeger et al., 1998b p. 141). In efforts to analytically assess climate change, we are confronted with technical, methodological and conceptual (epistemological) uncertainties (Funtowicz and Ravetz, 1990). Conceptual uncertainties are the most fundamental uncertainties. The difficulty in deciding how to consider intergenerational and interregional problems of climate change decision-making and its associated ethical dimension are just one of many conceptual problems in an integrated assessment of climate change.

All these problems call for the development of sound strategies and procedures of good practice to make integrated assessments (Bailey et al., 1996). Methods to manage the manifold uncertainties in an integrated assessment of climate change are in development (Funtowicz and Ravetz, 1990; Morgan and Henrion, 1990; van Asselt, 2000b, in preparation; van der Sluijs, 1996). An overview of classifications and typologies of uncertainty is given in (van der Sluijs, 1996) and (van Asselt, 1999).

2.1. IA MODELS

During the last decades, different IA methods emerged that can roughly be categorized in two classes: analytical methods and participatory methods (Rotmans, 1998). The most prominent analytical method in the field of global climate change is IA modeling. Other analytical methods are Scenario- and Risk analysis. Participatory methods will be discussed in Section 3.

Several dozens Integrated Assessment Models on climate change are available in the scientific community (van der Sluijs, 1997, p. 170; Weyant et al., 1996). Most of them have a global perspective on climate change. Different strategies to deal with uncertainties in IA-modeling can be roughly categorized into three categories: the 'Best-Guess Strategy', the 'Probabilistic Strategy' and the 'Pluralistic Strategy' (Pahl-Wostl et al., 1998).

'Best-Guess' strategies as used in some policy-optimization models are based on best guesses for parameters and for the model structure. The DICE model of William Nordhaus (1994) for example takes this strategy. 'Probabilistic' models use probability distributions for input parameters to make probabilistic assessments of climate change impacts. The ICAM model (Dowlatabadi and Morgan, 1993) is a prominent probabilistic IA-model. 'Pluralistic' models like the TARGETS model (Rotmans and De Vries, 1997; van Asselt and Rotmans, 1996) represent the most fundamental strategy for dealing with uncertainties in IA-models. TARGETS provides a set of different model structures based on different but equally justified conceptions of the climate change problem. This allows to incorporate uncertainties due to conflicting world views into the model. Pluralistic scenarios are based on different but equally plausible 'world views'.

While probabilistic and pluralistic models provide more realistic descriptions of the decision problem than best-guess policy optimization models, they are also more complex and therefore often more difficult to understand. The complexity of these models does not guarantee for a reliable description of the problem and for robust results. Some important processes as the non-deterministic nature of socio-economic developments are very complex to model and are not well understood.

Are global IA-models therefore useless to inform policymakers on the problem of climate change? If policymakers expect clear, simple and reliable answers to their complex problems the answer is surely ‘yes’. But decision-makers will often have to come to a decision without perfect information and their mental-models might be even more problematic than many IA-models. Another approach to think on the use of IA-models is to use them to gain new insights into complex problems and to improve the understanding of the decision problem. Instead of providing clear answers, IA-models can be used to illustrate and communicate complex issues. This suggests a new role for models as communication tools in participatory settings. We will discuss this new role for models in Section 3.

2.2. A REGIONAL PERSPECTIVE ON CLIMATE CHANGE

Most IA-models are global models that are sometimes divided into several world regions. Notwithstanding the dominant orientation towards global modeling, there is a growing need and interest in regional assessments, and thus regional IA-models (Cohen, 1997; Rotmans, 1998). Neither individuals, families, communities, nations, nor ecosystems experience either global mean surface air temperature, global mean precipitation or the average frequency of hurricanes, but rather the local manifestation of the global system: although climate is controlled globally, it is endured locally (Imboden, 1998).

The cause effect loop in regional integrated assessment is analytically very difficult to close. Downscaling of global climate change scenarios to regional climate change adds additional uncertainties to the assessment. Any regional policies to adapt to or mitigate climate change can only be judged given the policies pursued in other world regions. This makes some methodologies like best-guess based cost-benefit analysis very difficult to realize. Many regional integrated assessments are therefore carried out in the form of regional impact assessment with an emphasis on adaptation options. An additional problem is that regional action can hardly be linked unequivocally to regional consequences, because this link is contingent on cooperation on the global scale (Pahl-Wostl et al., 1998).

The IPCC approach to regional impact assessment and adaptation reflects the state-of-the-art in impact assessment (Parry and Carter, 1998). Different methods for impact assessment include models, empirical analogue studies and expert judgements. These methods are often mixed to provide an overall impact assessment. Fully integrated models do not play an important role in regional impact assessments. Instead of integrated models, many regional impact assessments build on a set of models. Expert judgements are used where it is difficult to make quantitative mathematical models of certain impacts and empirical analogue studies are used to validate models or as an input for the development of models. The MINK Study (Malone and Yohe, 1992; Rosenberg, 1993; Rosenberg and Crosson, 1991) is an example of such a study. Other regional impact assessments use similar approaches (Watson et al., 1998; Yates and Strzepek, 1998).

2.3. CLIMATE CHANGE IN THE ALPINE REGION

Mountain regions are potentially vulnerable to the impacts of climate change because of the combination of enhanced sensitivity to climate change and limited possibilities for species to migrate to favorable locations make mountains 'islands' in a 'sea' of surrounding ecosystems (Busby, 1988). This vulnerability has important ramifications for a wide variety of human uses and natural systems, such as nature conservation, land management, water use, agriculture, and tourism (Adhikary et al., 1996). The Alpine region is such a mountain region. By the Alpine region we mean the area bordered by the cities of Stuttgart (Germany), Vienna (Austria), Milan (Italy) and Marseilles (France).

The Alpine region is a key region for the study of global climate change from a regional perspective. Alpine weather and climate is influenced not only by large scale global forcing, but also by local topographic details. This demonstrates the importance of a regional approach to the problem of global climate variations. People in the Alpine region were continuously confronted with an unpredictable climate coupled with the vulnerability of both man and animals in an area where natural catastrophes are frequent and severe. The Alpine region is densely populated with a long tradition of direct democracy and a history of fundamental and innovative industrial transformations. This makes the region not only interesting to study anthropogenic climate change but also to study innovative socio-economic responses to climate change.

Few assessments of the impacts of climate change have been conducted in mountain regions compared to other biomes. One major reason is that impact assessment started in coastal areas where climate change can have a profound impact through the increase in the sea level. Other reasons are the difficulties in assessing impacts in the mountains as stated in the IPCC Second Assessment Report (1996) by Adhikary (1996):

- The complexity of mountain systems presents major problems for assessing the potential impacts of climate change. This applies to assessments of changes in both biophysical systems and social systems, the latter in particular because it is difficult to quantify the value of mountain regions in monetary terms.
- Tourism, being a key economic sector in mountain regions, is not a well-defined economic sector and is highly influenced by other factors than climate change. Especially winter tourism is sensitive to expected climate changes.
- The topography of mountains is so poorly resolved in most GCMs, that it is difficult to investigate the potential impacts of climate change.

In Switzerland, two major research projects have been initiated to assess regional climate change: the Swiss National Research Program 31 'Climate Change and Natural Hazards' (Bader and Kunz, 1998) (1992–1997) and CLEAR* 'Climate and Environment in Alpine Regions' (Cebon et al., 1998) Phase I (1992–1996) and Phase II (1996–1999).

Climate change scenarios for the Alpine region have been developed using different downscaling methods from empirical studies to statistical downscaling of GCM outputs, regional physical climate models nested in GCMs and high resolution GCMs (Gyalistras et al., 1998). Several important regional processes are still not well understood conceptually like the thermohaline circulation, the North-Atlantic-Oscillation (NAO) and the feedback between soil moisture, land use and precipitation. Some of these processes have characteristics of chaotic systems giving rise to inherent and therefore irreducible uncertainties in predicting regional climate change.

None of these research projects used an explicit integrated assessment approach. Instead of providing probabilistic statements on environmental, social and economic impacts, most impact studies depict potential vulnerabilities and orders of magnitude assessments. A position paper prepared by the researchers in the CLEAR project summarizes and highlights some fundamental insights into regional climate change from a scientific perspective. Table II summarizes those insights.

A variety of socio-economic effects associated with climate change can be expected in the Alpine region from global climate change. Sectors that are directly dependent upon climate conditions are tourism, agriculture and forestry. Around 10% of the active population in Switzerland is working for the tourism sector. About half of the turnover is made in winter. There are indications that winter tourism could suffer from climate change due to shorter winter seasons. If the tourism sector were static and non adaptive, many skiing regions in Switzerland would become unprofitable within the next 30 to 50 years. But these losses could be compensated by adaptive measures like the use of snow canons, evasion to higher altitudes and alternative tourist offers. The future of Swiss tourism will be dependent on many factors like consumer preferences and the relative cost level for tourism in Switzerland. Climate change is one of those factors (Abegg et al., 1998). This at least indicates that people working in winter tourism must consider the prospect of a climatic change.

A recent study by Meier (Bader and Kunz, 1998) tried to estimate total economic costs to Switzerland for an increase in average temperature of 2 °C. He calculated a loss of 2.3 to 3.2 Billion SFr. per year. This is 0.6 to 0.8% of the Swiss GDP. Most of the costs are due to losses in winter tourism. Such economic estimates are highly uncertain. The assessment is conservative in the climate change scenario used and did not reflect adaptive responses. The costs could be much lower if cheap adaptive responses would be considered and much higher if a stronger climate change or even an abrupt climate change would be considered. Also non-economic impacts and impacts due to economic consequences in other world regions are not considered.

Other assessments suggest that although some economic sectors like winter tourism will be challenged by climate change, climate change is not assumed to pose a major economic threat to the Alpine region over the next few decades (Jaeger et al., 1998a). None of these studies is based on an in-depth integrated assessment of climate change in the Alpine region.

We conclude that there is a growing need for regional integrated assessments that complement global assessment efforts. The Alps form a key region for an integrated assessment of climate change, because they are especially vulnerable to climate change and because there remain many conceptual and inherent uncertainties in predicting and assessing regional climate change impacts.

3. A Participatory Approach to IA of Regional Climate Change

The question remains how scientific insights can be made useful to a decision-making process on regional climate change. In the next section we outline our approach to integrated assessment that draws heavily on the ideas expressed in the final chapter (Pahl-Wostl et al., 1998) of the CLEAR I book 'Views form the Alps: Regional Perspectives on Climate Change' (Cebon et al., 1998). We assert that a pluralistic and participatory approach is a useful complement to other integrated assessment methods, especially in regional climate change context. Any evaluation of potential impacts of climate change must take into account subjective judgements based on moral, esthetical and economic considerations. Questions related to climate change have therefore to be embedded into a wider context of societal concerns.

3.1. PARTICIPATORY IA METHODS

Participatory Integrated Assessment methods (PIA) complement existing analytical methods by assessing a broader context of societal decision making. Human participants are interacting with one another and with expert knowledge in a structured and decision oriented setting. Participatory methods are seen as an important tool to make integrated assessments more stakeholder-oriented and to integrate a broader range of societal concerns (Parson, 1997; Rotmans, 1998; Schneider, 1997).

Participatory IA methods can roughly be grouped into three categories: dialogue methods, policy exercises and mutual learning (Rotmans, 1998; van Asselt, 2000a, in preparation). In dialogue methods, intended users are a source of information to design and test other assessment methods like IA-models. In the Delft process for example a test group was used to design meaningful model runs with the IMAGE model (van Daalen et al., 1998). Policy exercises build on the tradition of simulation-gaming methods. Human participants play roles in a structured relevant decision and task setting exercise (Parson, 1997) with a simplified representation of

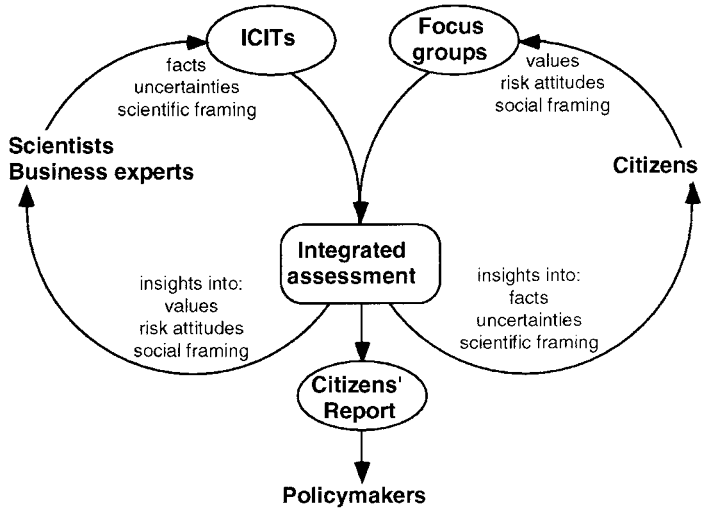


Figure 1. Participatory IA as a process of social learning: IA-focus groups with Interactive Citizens' Information Tools (ICITs).

a complex system (Toth, 1988). A policy exercise is a means to get information on human behavior and policy preferences necessary for an integrated assessment. It also allows for detecting new and surprising policy options. The RIVM's SusClime exercises (de Vries, 1995) and climate change policy exercises (Parson, 1997; Parson, 1996) are examples of policy exercises that made use of 'tailor-made' IA-models.

In mutual learning methods, human participants enrich the assessment and are regarded as co-producers of knowledge (Rotmans, 1998). Participants are incorporated in the integrated assessment because their skills or competence complement the scientists' expertise and knowledge. The 'focus group approach' is an example of a mutual learning method (Dürrenberger et al., 1997; Kasemir, 1997).

We see our approach to Integrated Assessment as a process of social learning among citizens, scientific experts and policymakers (see Figure 1). Social learning is more than just transferring information from one social group to another one. It involves the development of a shared understanding of the problem among different societal groups and involves the formation of new or the transformation of already existing institutions (Minsch and et al., 1998; Schneidewind et al., 1997). This process of social learning involves a polycentric understanding of policy making (Pahl-Wostl et al., 1998).

We focus on citizens as important stakeholders and decision-makers in the Alpine region. Citizens' lifestyle choices and their acceptance or rejection of climate-related policy options influence policy-making at all levels. Information about their framing of the problem, their value judgements and their attitudes towards climate risks can yield important insights for policymakers and the research community. Policymakers on the one hand depend either directly or indirectly on citizens' voting and elections. Insights into citizens' judgements can help them to design policy strategies that are more adapted and more likely to be accepted by the public at large. Scientists on the other hand can use insights form IA focus groups to better adapt their research directions to societal needs and to improve the way scientific knowledge is made available for a broader audience.

In a process of social learning, citizens may learn how scientists perceive the problem of climate change, what are the facts and what are the uncertainties. Scientists may learn how citizens respond to scientific input, how they judge the information and how they cope with the uncertainties involved in assessing climate change. The result of this process may be a better understanding of how citizens perceive and value climate change and how they interact with scientific information. These insights can then be used to improve future policy recommendations and research directions to better take into account the needs of regional policy-making.

Research in risk perception and communication suggests that, despite widespread media coverage of global climate change and related issues, lay mental models suffer from several basic misconceptions and irrelevant beliefs (Bostrom et al., 1994; Read et al., 1994). As we are interested in an informed judgement of climate change and in a process of social learning, it is essential to provide citizens with state-of-the-art expert knowledge on climate change.

3.2. OUR APPROACH TO PIA: IA FOCUS GROUPS WITH INTERACTIVE INFORMATION TOOLS

A process of social learning involves information exchange and an institutional framework where this exchange can take place. IA focus groups are our institutional 'micro-cosmos' to test the exchange information with citizens. Interactive Citizens Information Tools (ICITs) are the interface to provide state-of-the-art scientific information to the citizens in an accessible and user-friendly form. The specific role of ICITs is not only to transfer scientific information to the citizens but also to support citizens in learning how scientists frame and assess the whole problem. The whole focus group process is mediated by sociologists. The overall objective of IA-focus groups is to produce policy-recommendations on complex problems. Integrated assessments based on such a process of social learning may complement and enrich other assessments because IA-focus groups in principle generate policy recommendations that synthesize and integrate a wide variety of scientific information as well as social, political and ethical valuations.

The focus group method for integrated assessment (IA-focus groups) is a participatory method developed within the two research projects CLEAR and ULYSSES (Dürrenberger et al., 1997; Dürrenberger et al., 1999; Kasemir et al., 1999; Kasemir, 1997). IA focus groups draw on elements of both public opinion research and marketing studies. They differ from both fields in their explicit goal of

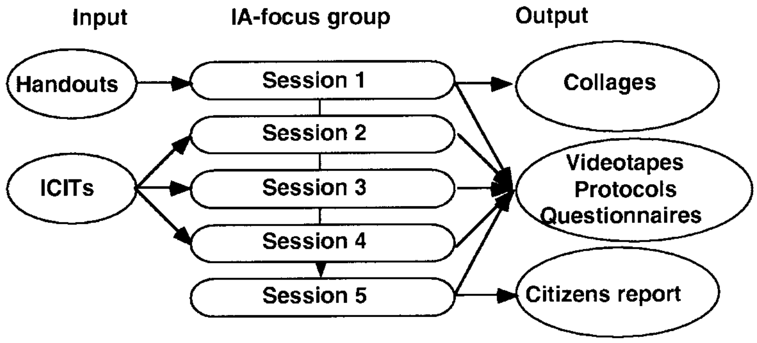


Figure 2. IA-focus group design.

providing ordinary citizens as well as various other stakeholders with an opportunity to articulate their voice in the climate change debate, and to do so in a way that draws on the state-of-the-art in scientific research and that is suitable for shaping actual policy making.

With IA-focus groups, the following questions may be clarified:

- How do citizens use scientific input?
- How do they cope with uncertainties?
- How do informed citizens judge the risk of climate change?
- What policy options do they prefer?
- What are their policy recommendations?

In the following we refer to the IA-focus group design used in the CLEAR project (Willi and Dahinden, 1998).

Each focus group consists of 5 sessions with around six to eight participants, a moderator and a person keeping the minutes. The recruitment is based on quota criteria concerning age, sex and environmental attitude. All sessions are recorded on videotapes. During the first session, participants are informed about the topic of the discussion and produce collages on their vision of a business-as-usual and a low-energy scenario for Switzerland. Sessions two to four are devoted to discuss climate change from a regional perspective. Expert knowledge on climate change impacts and on policy measures is provided by some handouts and particularly by computer based Interactive Citizens' Information Tools (ICITs). In the last session, participants produce a citizens' report. This report contains the citizens' risk assessment of climate change and their policy recommendations (see Table III). Four questionnaires were used to elicit the citizens' assessment of climate change and of computer tools before and after the information input. Figure 2 illustrates the inputs and outputs of the focus groups.

Table I
IA-models vs. ICITs

IA models	ICITs
Analytical IA method	Part of a participatory IA method
Built to analyze a problem	Built to inform about a problem
Targeted towards an expert audience	Targeted towards citizens
Results of model analysis are conveyed to decision-makers and stakeholders	ICITs itself are interactively used by decision-makers and stakeholders
Quantitative and internally consistent information	Quantitative, qualitative and conceptually coherent information
Difficult to include subjective judgements, preferences, values and conceptual uncertainties	Allow to include subjective judgements, preferences, values and conceptual uncertainties
Not self explaining	Extensive explanations
Often contain normative overall assessments	Overall assessment made by the citizen after working with ICITs

3.3. THE CLEAR INFORMATION PLATFORM

We developed a framework of ICITs that is specifically targeted towards IA-focus groups with citizens: The CLEAR Information Platform (http://CLEAR.eawag.ch). It was developed in the second Phase of CLEAR that started in 1996 and lasted until the end of 1999. The Platform builds on World Wide WWW technology and can be accessed with a standard WWW-Browser.

Citizens are not primarily interested in climate change as such. They want to know how climate change relates to their daily life, to society as a whole and how it compares to other global and regional problems. The CLEAR information platform aims to inform and to stimulate discussion about the following topics:

1. Main causes of anthropogenic climate change.
2. Possible regional impacts of climate change – not only in monetary terms but also in terms of change in the natural, economic and social system with regard to aesthetic and ethical considerations.
3. Uncertainties in assessing regional climate change and climate change impacts.
4. In addition to regional considerations, citizens also care about global impacts and cross regional equity. Therefore, information about impacts in other world regions is also provided.

5. Rough assessments of the relevance of climate change impacts in comparison to other likely changes.
6. Information on political, economical and individual regional options to cope with the prospect of climate change.

This list of topics is based on discussions with social and natural scientists within CLEAR and reflects the scientists' view on relevant information for citizens.

As depicted in Section 2, the general complexity of the climate change problem with its huge and irreducible uncertainties together with the problem of linking local actions to local climate change prohibits a straight forward best-guess and cost-benefit analysis based on a comprehensive formal simulation model. Therefore we decided to develop three distinct ICITs that convey different aspects of state-of-the art knowledge on regional climate change:

- *'Personal CO_2-Calculator':* a tool to link citizens lifestyle choices to the problem of anthropogenic climate change by calculating personal energy and CO_2 balances based on a questionnaire on lifestyle choices (Schlumpf et al., 1999).
- *IMPACTS:* an information tool about causes and impacts of climate change from a regional perspective with an emphasis on inherent and conceptual uncertainties in predicting climate change and its impacts.
- *OPTIONS:* an information tool about regional policy options for addressing climate change with an emphasis on visions for a low energy society.

4. Impacts

4.1. GOAL AND REQUIREMENTS

The overall goal of IMPACTS is to allow citizens to make their own risk judgements of anthropogenic climate change based on credible scientific information. IMPACTS is therefore an information tool about causes and impacts of anthropogenic climate change from a regional perspective. As an information system IMPACTS is intended to convey and explain scientific insights derived form the CLEAR project (see Table II). The main topics to be covered by IMPACTS are:

- The pressures behind anthropogenic climate change and the range of likely global climate change.
- Expected regional climate changes and associated uncertainties.
- Description of a comprehensive range of regional impacts in ecological, social and economic terms including uncertainties in assessing regional impacts.
- Likely impacts of climate change in other world regions to allow users comparing regional and global trends.

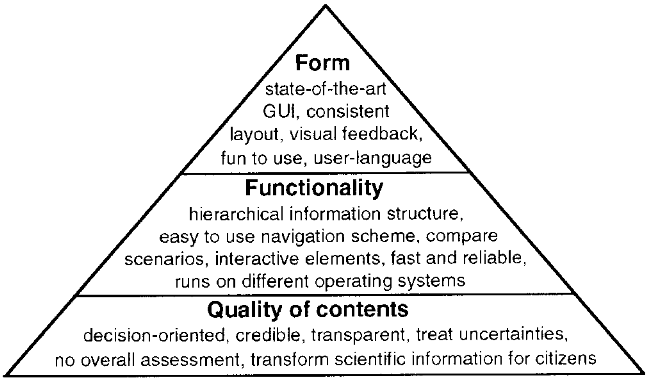


Figure 3. A Pyramid of requirements for designing IMPACTS.

As the citizens are confronted with IMPACTS in IA-focus groups, IMPACTS has to be flexible in providing easy and immediate access to a broad range of information. In order to reach its goals, IMPACTS has to fulfill several requirements concerning the quality of contents, the functionality of the tool and the form in which the information is presented. These requirements are depicted as a 'pyramid of requirements' (see Figure 3), which we used as a mental model for the building of IMPACTS. The requirements at the higher levels only make sense, when the ones at the lower level are fulfilled.

These requirements are important for IMPACTS as a whole as well as for each of its information parts and multimedia elements.

4.2. CLIMATE CHANGE SCENARIOS FOR THE ALPINE REGION

IMPACTS is based on a top-down approach to represent regional impacts of climate change. First, we selected two global scenarios of climate change. Then we developed two regional climate change scenarios based on the two global scenarios.

4.2.1. *Global Climate Change Scenarios*

For each step of the top-down approach, we used different methods. The global climate change scenarios are taken from the IPCC 1995 report (Houghton et al., 1996). Instead of selecting a best guess scenario we decided to take two scenarios that encompass the range given by the IPCC Report: 'weak climate change' and 'strong climate change' (see Table IV). We did not include a best-guess scenario because we intended to emphasize the range of uncertainty.

'Weak climate change' corresponds to the emissions scenario IS92c with a low climate sensitivity of 1.5 °C. 'Strong climate change' corresponds to the emissions scenario IS92e with a high climate sensitivity of 4.5 °C. In the 'strong' scenario we did not include the effect of increasing aerosol emissions. One reason for this was that we the disciplinary projects within CLEAR were not able to provide scientific information on regional climate change scenarios that include aerosols. The

Table II

Fundamental scientific insights into climate change in the Alpine region for the second half of the next century, when a doubling of the greenhouse concentrations is expected

- Temperature increase by 1–4 °C; more pronounced in the area north of the Alps in winter and at higher elevations.
- Precipitation increases; particularly pronounced in the Southern Alps during autumn, winter and spring.
- A shift from snowfall to rainfall at intermediate Alpine levels, due to higher winter temperatures.
- An increase in zonal flow regimes, i.e., enhanced occurrence of meridional weather types and an accompanying increase in weather variability.
- Many processes are not well understood in predicting regional climate change. There is a potential for 'surprises' and abrupt climate changes, although they are considered unlikely to take place.
- Frequencies of extreme precipitation events might be very sensitive to climate change.
- A continuing retreat and extinction of Alpine glaciers, especially of small ones at lower altitudes.
- The destabilisation of steep mountain slopes is a likely result when Alpine permafrost zones retreat to higher elevations and this may significantly endanger some of the currently inhabited places.
- Despite huge uncertainties, climate change presents a threat to Alpine ecosystems especially in the long term because Alpine ecosystems are highly sensitive to climate changes and they are strongly bound to specific regions or locations.
- A variety of socio-economic effects must be expected in the Alpine region from global climate change. Although some of the effects may be dramatic at the very local level, no effect could so far be isolated, for which – during the next 50 years – impacts are so serious that they rival those from natural and anthropogenic origins in the past.
- Although some economic sectors like winter tourism will be challenged by climate change, climate change is not assumed to pose a major economic threat to the Alpine region over the next few decades.

second reason was that it might well be desirable to limit aerosol emissions in the future for health considerations in spite of the 'weakening' effect of aerosols on climate change. The considerations explained together with the two scenarios in IMPACTS.

In order to support an understanding of the sources of uncertainty behind these two scenarios, a simple simulation model is included in IMPACTS: the 'Causes-model' (see Box 1).

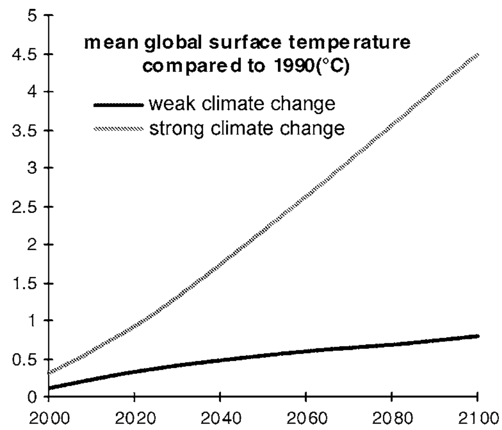
Table III

Structure of the citizen reports. The focus group participants had to base their citizen report on the following questions

- Is climate change a problem, today or in the future? If yes, what is the problem in your view?
- How should we be living 30 years from now?
- What should be done to achieve this?
- By how much should energy consumption be lowered in total and in different sectors?
- Who should do something and when?
- Where do you see problems in achieving this?

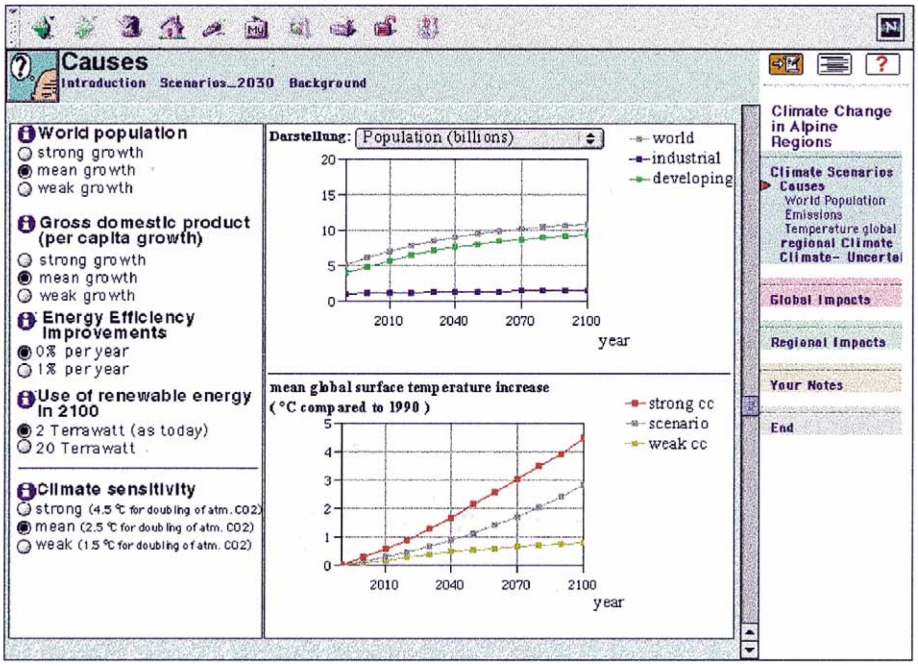
Table IV

Two scenarios for mean global temperature increase

Global scenarios in IMPACTS	Weak climate change	Strong climate change
Emission scenario	IS92c	IS92e
Climate sensitivity	1.5 °C	4.5 °C
Mean global surface temperature increase		

Box 1: The Causes-model

This Causes-model provides a set of scenarios for mean global temperature change over the next 100 years. The user can choose scenarios for CO_2-emissions based on population, economics and energy scenarios as well as scenarios for the sensitivity of the climate system. Each of these factors can be changed in the range as depicted in the IPCC 1995 reports. The resulting set of scenarios is within the range of the IPCC 1995 scenarios for mean global temperature increase. Each uncertain factor is explained with separate information boxes and the reasons for the uncertainties are depicted. The figure displays the user interface of the Causes-model. The user can choose between a predefined set of options for each factor. The (i) button directly invokes an explanatory screen for each factor. The result of any combination of options is immediately calculated and visualized in the form of two graphs. The upper graph allows the user to view different variables and the lower graph displays the resulting increase in mean global temperature. The two scenarios that span the range of uncertainties, called 'weak' and 'strong' scenario are always shown for comparison.



4.2.2. *Regional Climate Change Scenarios*

The two global temperature scenarios can be used as a starting point to develop detailed regional climate change scenarios. We decided to follow a twofold strategy to develop such scenarios. First, IPCC scenarios of regional climate change were used to build two climate change scenarios for Southern Europe. Secondly, more

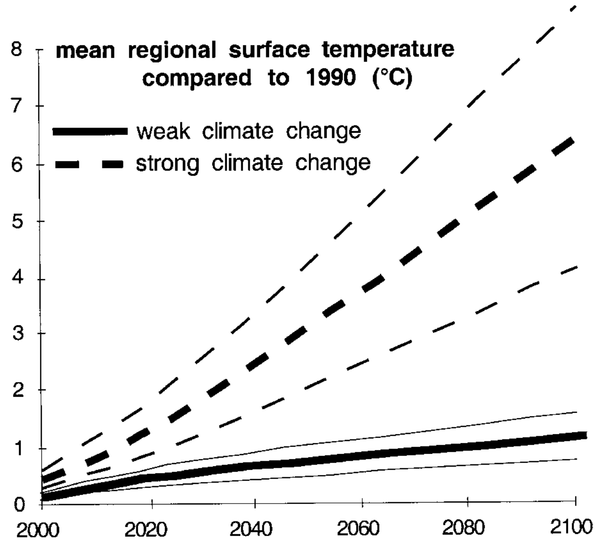


Figure 4. Temperature scenarios for southern Europe. The two scenarios are based on two different global temperature scenarios. The thin colored lines indicate the range of uncertainty of each scenario. The gray box indicates the time horizon that was used to develop the statements on climate change in the Alpine region.

detailed statements for those two regional climate change scenarios were developed in collaboration with the CLEAR scientists.

Six different GCM runs were used to assess the climate sensitivity of mid and Southern Europe (Houghton et al., 1996, figure 19). These sensitivities were then compared with the global climate sensitivities of the GCMs. The results indicate that the climate sensitivity of Southern Europe might be greater than the sensitivities of global mean temperature (the factor being 1.4) with a large standard deviation due also to the small set of only 6 GCM runs evaluated. Taking the 90% intervals of the calculated climate sensitivities, the climate sensitivity of southern Europe might be between 1.4 °C and 8 °C with a mean of 3.6 °C.These climate sensitivities are then applied to the two global climate change scenarios to get a first estimate of the range of regional temperature increase. Figure 4 shows the two climate change scenarios for southern Europe. They were the starting points for the compilation of statements on climate change in the Alpine region.

4.2.3. *Statements on Regional Climate Change*

Mean changes in temperature are not a sensible proxy for assessing climate change impacts. Therefore we relied on the expertise of climate experts within the CLEAR project as well as on scenarios developed for the NFS 31 project to transform the temperature scenarios for southern Europe into more comprehensive climate change scenarios for the Alpine region. Based on this expertise, we developed a set of statements on climate change in the Alpine region for the time horizon

Table V
The two climate change scenarios in IMPACTS: 'strong' and 'weak'

	Weak climate change	Strong climate change
Atmospheric CO_2-concentration	+50% by 2100	+300% by 2100
Mean global surface air temperature (compared to 1990)	+0.4 °C by 2030 +0.8 °C by 2100	+1.3 °C by 2030 +4.4 °C by 2100
Mean surface air temperature in the Alpine region	+0.3 to +0.7 °C by 2030 +0.5 to +1.0 °C by 2050	+1.0 to +2.5 °C by 2030 +2.0 to +4 °C by 2050
Local and seasonal difference in regional temperature increase	Increase is more pronounced in the nights Increase is more pronounced north of the Alps and in winter Increase might be more pronounced at higher altitudes Increase is strongly coupled with precipitation scenarios	
Mean regional annual precipitation change	–5 to +10% by 2030	In winter up to +30% by 2030 Development in summer is unknown
Change in strong precipitation events	Slight increase in extreme precipitation events by 2030	Possibility of a strong increase in extreme precipitation events by 2030

between 2030 and 2050 (see Table V). In addition, we used results of downscaling exercises to visualize potential spatial variabilities of temperature and precipitation of a climate change in Switzerland (see Figure 5). In some fact sheets on specific impacts (e.g., tourism, agriculture), climate change scenarios were used that are consistent with the statements but provided much more detail than the two standard scenarios.

4.3. METHOD USED TO BUILDING IMPACTS

The method for building IMPACTS can be divided into two main areas: the software and the contents. Figure 6 shows the steps of importance in building IMPACTS.

The development of the software was an iterative process involving disciplinary scientists, the group that designed IMPACTS, focus group moderators and citizens. Initially, disciplinary scientists, the group that built IMPACTS and the moderators discussed contents and design of IMPACTS. A first prototype was produced and

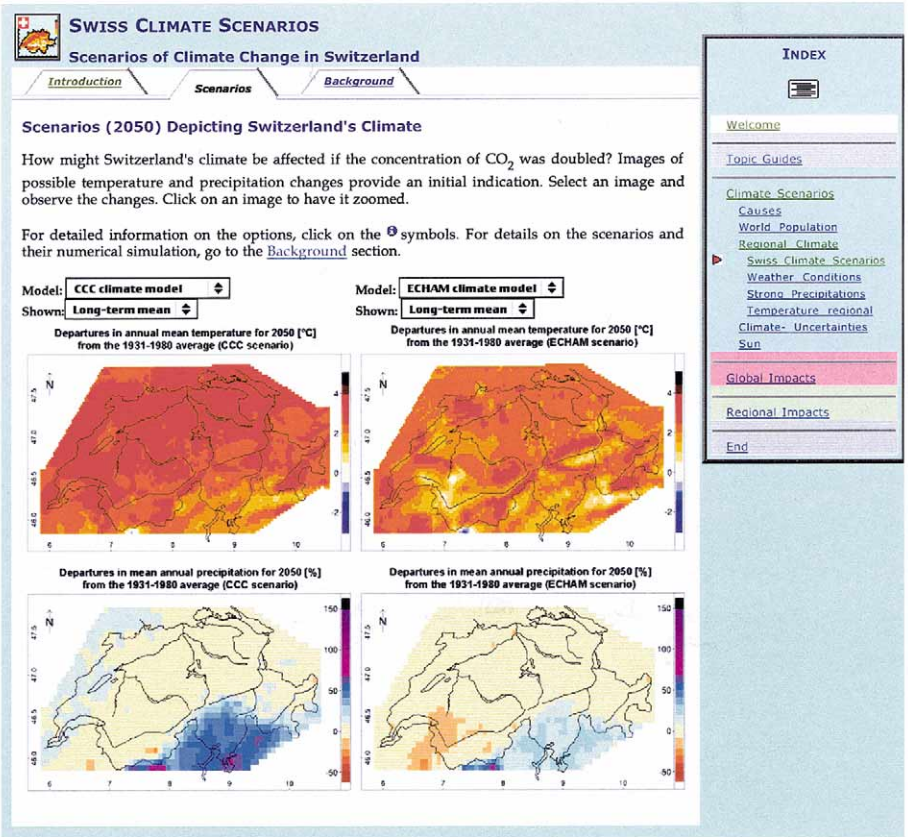


Figure 5. Spatial variability in mean annual temperature and precipitation changes based on a stochastic downscaling experiment with two different GCM models for a doubling of the CO_2 concentration. The figure shows the user interface in IMPACTS. The user can choose between two GCM models and between 6 different maps indicating variability among different years.

tested in pretest focus groups. Experiences with the pretest focus groups were then used for the final design of IMPACTS and the focus groups. The user interface design was based on the principles depicted in Section 4.4.

The method for gathering and preparing the contents of IMPACTS involved several steps. First, we developed the two scenarios for global climate change that encompass the range of the IPCC scenarios. Then we developed two climate change scenarios for regional climate change based on these two global scenarios. In a second step, these two regional scenarios were adjusted and expressed in a set of statements for the year 2030 with the help of the disciplinary scientists within CLEAR.

We provided the domain experts with the scenario statements for the two regional climate change scenarios (see Table V) and an outline of the structure of a fact sheet (see Table VI). We already prepared a first draft of the contents, if

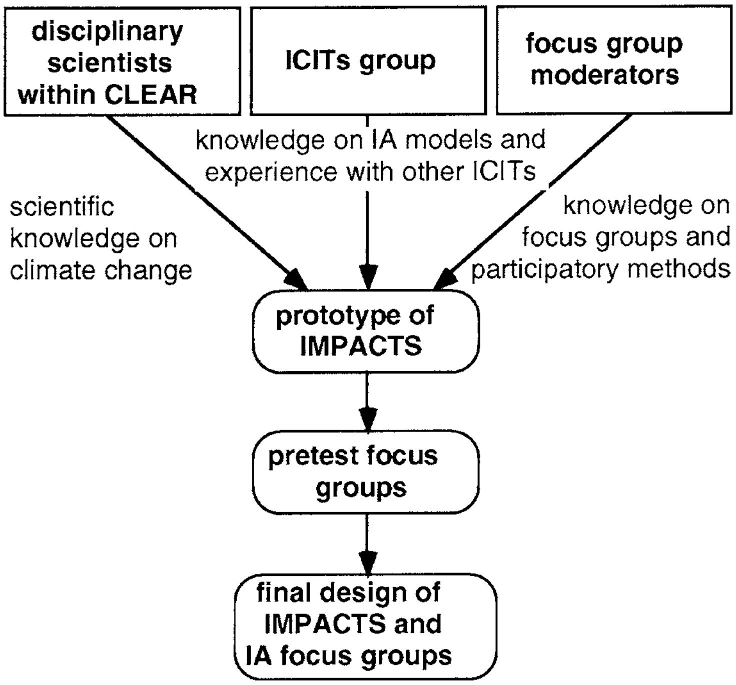


Figure 6. Method for designing the IMPACTS software.

possible. The domain experts then reviewed and redrafted the fact sheet. We implemented a first version of the fact sheet in IMPACTS and the domain experts then reviewed the fact sheet on the Internet. In a last step, we included pictures, implemented interactive devices and inserted links.

Three different communities were involved in the gathering and processing of information for IMPACTS – Scientists within the coordinated project CLEAR, the scientific community at large and business experts outside the scientific community at the national level.

Information about global climate change and global scale impacts were drawn from the literature, especially form the IPCC reports (Bruce et al., 1996; Watson et al., 1996).

Most of the fact sheets on regional climate change and on regional impacts were developed in collaboration with disciplinary projects within CLEAR that could rely on research results and interdisciplinary cooperation established during the first three years of research within the CLEAR project (Cebon et al., 1998). In addition, expertise from other scientists and business experts was needed because the range of disciplines in the CLEAR project did not encompass all topics relevant to build IMPACTS. Most of the expertise was gathered by direct communication with experts. This direct contact with researchers and business experts was a prerequisite to preparing credible and high-quality contents for the fact sheets.

Table VI
Structure of the fact sheets

Part of fact sheet	Contents
Introduction	Icon Introductory text Questions Image Links to other parts of facts sheet
Climate scenarios	Expert statements for two climate change scenarios A statement for abrupt climate change Statements on other important influences Time horizon: 30 years Explanations for most statements
Background	General introduction Historical development Current trends (irrespective of climate change) The role of climate change Subjective statements of domain experts or stakeholders Bibliographic references
Goodies	Animations Movies Interactive simulation models

4.4. DESIGN OF IMPACTS

The design of IMPACTS is based on several components to fulfill to the requirements regarding quality of contents, functionality and form:

- A hypermedia navigation scheme and graphical user interface.
- A hierarchy of fact sheets covering a comprehensive range of topics and providing a ‘story line’ for users.
- A consistent and citizen-oriented contents and structure for all fact sheets.
- A scheme for communicating uncertainties.
- Dynamic and interactive elements like animations, movies and simple simulation models.

The scheme for communicating uncertainties and the dynamic elements are discussed in Section 5.

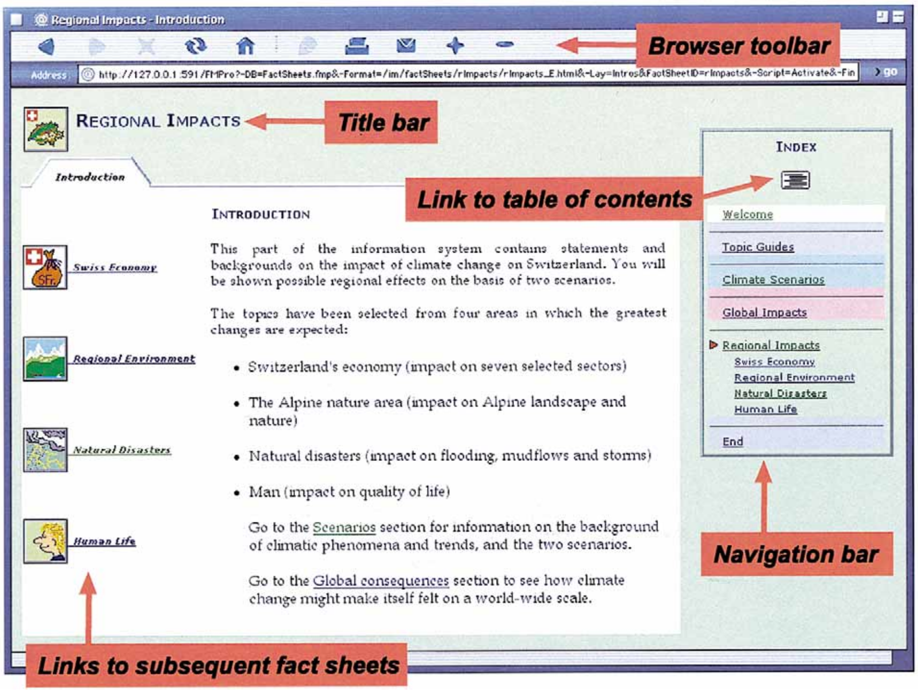


Figure 7. Introductory screen for the fact sheet on regional impacts. The user interface consists of four elements. The browser toolbar at the top allows you to follow your own path back and forth through the fact sheets. The navigation bar on the right shows the hierarchical structure of the information system with a red arrow indicating the position of the visible fact sheet. A button linking to the table of contents is also included in the navigation bar. The title bar contains the name and icon of the visible fact sheet and provides access to the scenario statements and background information. The large frame in the center shows the contents of the fact sheet with links to subsequent fact sheets and an introductory text.

4.4.1. *A Hypertext Navigation Scheme*

As the main functionality of IMPACTS is to provide access to a broad range of information and to let users navigate through this information, we decided to build IMPACTS as a hypermedia information system using a WWW-Browser as graphical user interface. Current Internet-Browsers provide links, bookmarks, browsing histories and support various multimedia formats. IMPACTS strongly builds on these functions to provide users easy access to the information. Additionally, IMPACTS offers a navigation bar that allows users to navigate the hierarchical structure of the information tool and a map with an overview of all topics in IMPACTS. Carefully selected cross-references allow users to jump between related topics. A consistent color scheme indicates which part of the information system the user is visiting at the moment. Figure 7 shows a screenshot of IMPACTS with its navigation elements.

4.4.2. *A Hierarchy of Fact Sheets Covering a Comprehensive Range of Topics and Telling the Story of IMPACTS*

The main information elements in IMPACT are the so called ‘fact sheets’. Every fact sheet is devoted to a specific topic. They are hierarchically organized to give users a structured access to the contents of IMPACTS. Figure 8 gives an overview of all 45-fact sheets. The topics were selected in collaboration with the disciplinary scientists within CLEAR and the sociologists working on the focus group method.

The fact sheets tell a ‘story’ if visited one after the other. The story line of IMPACTS starts with the anthropogenic forcing of global climate change and focuses then on scenarios for global and regional climate change as well as uncertainties in climate change. The main part of the story is then devoted to the description of possible impacts on a global level and in the Alpine region. The combination of hypermedia navigation support, hierarchical structure and a general story line allows the users to choose different pathways through the information tool without losing oversight.

4.4.3. *A Consistent and Citizen-Oriented Contents and Structure for All Fact Sheets*

Only the information that the CLEAR scientists considered to have some relevance for citizens in their assessment of climate change is included. We decided on the relevance of the information by asking the domain experts to motivate why citizens should care about a specific information. Secondly, we discussed the information with social scientists that had experience in working with focus groups.

The introduction is composed of a small icon that is a metaphor for the topic discussed in the fact sheet; a short introductory text that explains the topic; some questions as teasers; links to the other parts of the fact sheet and an image. If a fact sheet has some subsequent fact sheets, this image contains links to those fact sheets.

The ‘scenario statements’ part of the fact sheet contains expert statements for the two scenarios weak and strong climate change. In the fact sheets on impacts, ‘scenario statements’ contain expert statements on likely impacts for these two climate change scenarios in ecological, economical and societal terms. A total of 250 impact statements is at the heart of the information tool. The time horizon of the scenarios is the next 30–50 years. Most statements are made for the years between 2030 and 2050. This time horizon is short enough to allow citizens to think of themselves or at least their children living in that time but long enough that climate change impacts can be expected to unfold. Most of the statements are backed up with explanations and references that are just one mouse-click away. This makes the information tool transparent. Additionally, potential impacts of an abrupt climate change are discussed as well as important non-climate influences for the future development of the topic under consideration.

The ‘background’ part of the fact sheet contains more detailed information on the topic and a list of bibliographic references. This information is composed of

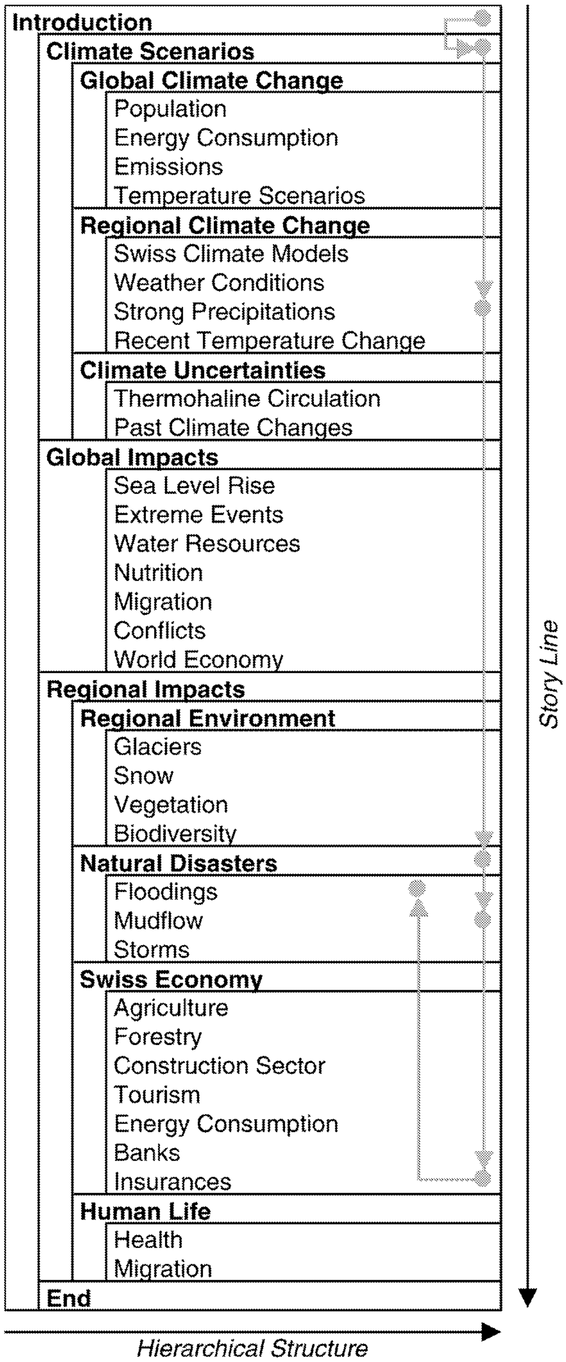


Figure 8. Overview of all fact sheets in IMPACTS. Hierarchy of fact sheets (left to right) and ‘story line’ (top to bottom). The grey graph depicts a path through the fact-sheets.

Table VII
Uncertainties and their representation in IMPACTS

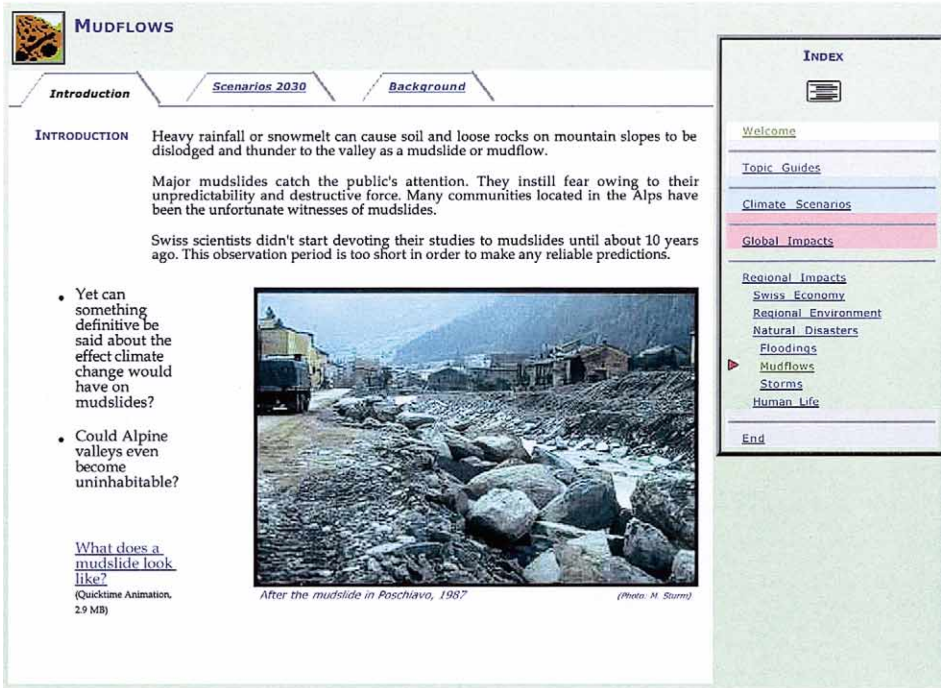
- *Uncertainty in anthropogenic forcing and climate sensitivity*
  Interactive simulation model for global temperature scenarios (Causes-model)
- *Uncertainty in global climate change scenarios*
  Two distinct global climate change scenarios that span the range of uncertainty. No best-guess scenario.
- *Unlikely, but possible surprises*
  Interactive simulation model on thermohaline circulation. All fact sheets on impacts include an explanation of the impacts of an abrupt climate change.
- *Uncertainty in regional climate change*
  Statements on regional climate change based on two global climate change scenarios.
- *Variability of regional climate*
  Text on Wetterlagen and 'North Atlantic Oscillation' phenomenon.
- *Uncertainty in regional impacts*
  Statements on regional impacts based on the two regional climate change scenarios.
- *Likelihood of different impacts*
  Careful and consistent wording, starting with the most likely impacts.
- *Possibility of increase in extreme events*
  Fact sheet on extreme events with an illustrative 'strong precipitation model'.

a general introduction, historical developments, current trends (irrespective of climate change), the role of climate change, some subjective statements of domain experts and bibliographic references.

The 'goodies' are special interactive and multimedia elements of fact sheets. The fact sheet on mudflows, for example, contains a movie depicting the effect of a mudflow on a small Alpine village. The most important goodies are interactive simulation models. The fact sheet on climate scenarios, for example, provides a simulation model for scenarios of global mean temperature change over the next 100 years based on published scenarios (see Box 1). The user has a number of predefined choices to alter parameter settings and assumptions that allow to explore the full range of uncertainties.

Table VII summarizes the four part of each fact sheet: An introduction, climate change scenario statements, background information and goodies. The user visits first the introductory screen of a fact sheet and subsequently decides if he wants to go to the other parts of that fact sheet, to a subsequent fact sheet or to another part of the information tool. Figure 9 shows the four parts of the mudflow fact sheet.

(a)



(b)

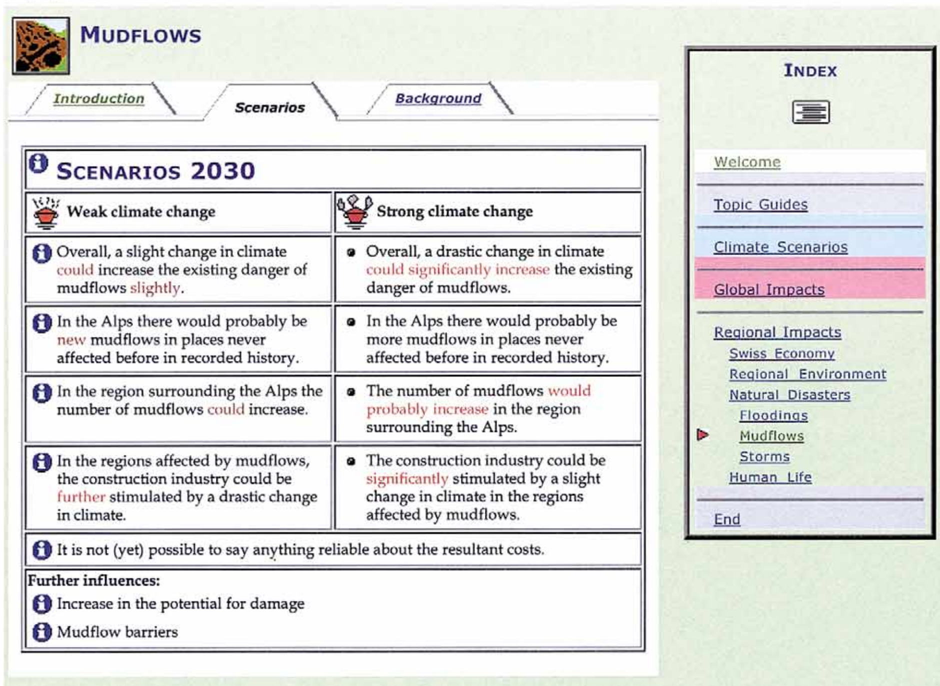
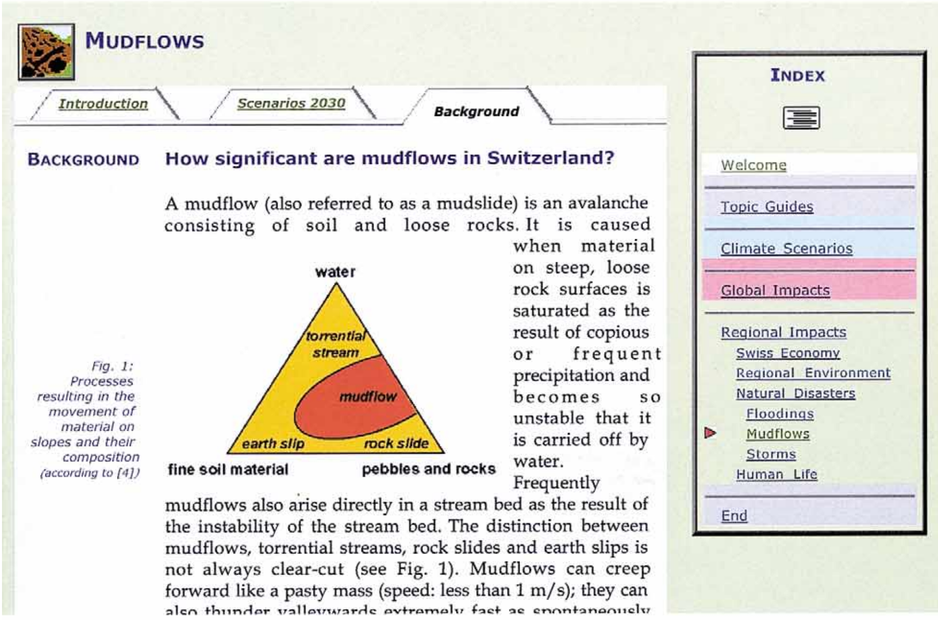


Figure 9a, b.

(c)



(d)

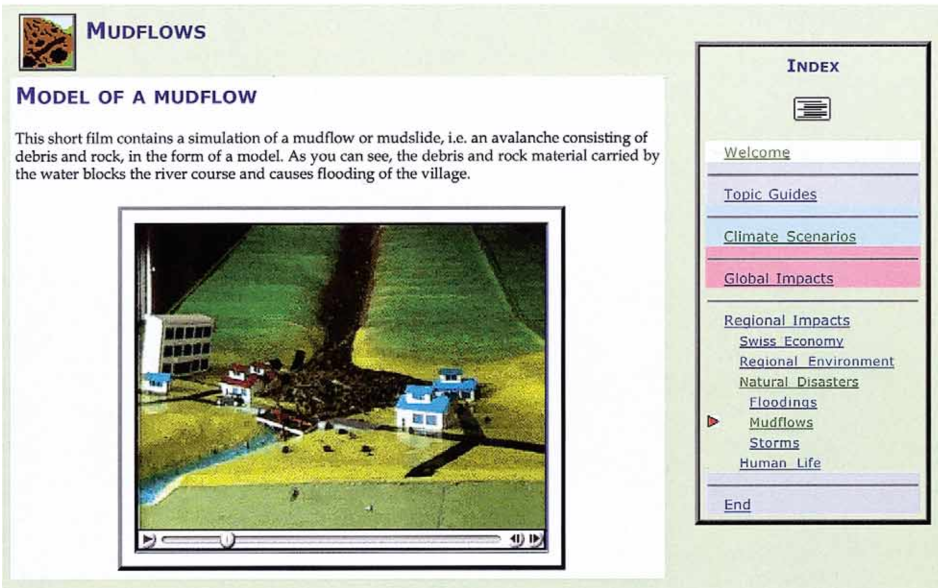


Figure 9c, d.

Figure 9. The four parts of the Mudflow fact sheet. The Introductory part (a) introduces the phenomenon of mudflows. The scenario statements (b) list expert statements on the likely impact of climate change on mudflows based on two scenarios. The background part (c) provides a comprehensive coverage of the processes behind mudflows and the historical trends. As a goodie, the fact sheet contains a movie that exemplifies the effect of a mudflow on the model of a small Alpine village (d).

5. Communication of Uncertainties with ICITs

As IMPACTS informs about climate change and potential impacts, it is essential to inform about uncertainties in predicting climate change and in assessing impacts. We developed a scheme to communicate different types and sources of uncertainties. Three types of uncertainties in assessing climate change are presented in IMPACTS:

- uncertainties leading to different transient scenarios of global climate change,
- uncertainties due to the complexity of the climate system that could produce unexpected climate changes – low probability high risk events,
- uncertainties in regional climate change impacts.

Table VII gives an overview of the elements in IMPACTS that are used to inform about uncertainties. Uncertainties leading to different transient scenarios are presented with the 'Causes-model', a simple carbon-cycle and climate-simulation model that calculates scenarios of mean global surface temperature increase (see Box 1). This interactive model allows users to test different uncertainties in the causes of climate change. The result is a set of possible scenarios of mean global temperature increase.

Uncertainties that could lead to surprises like abrupt climate change are depicted with separate fact sheets that include also small simulation models to convey insight in the non-linearity of the climate system. A simulation model on the thermohaline circulation, for example, explains the unlikely but possible event of a breakdown of the thermohaline circulation in the North Atlantic that could have a mayor impact on the climate in Europe.

The regional temperature scenarios are based on the global scenarios that span the range of possible global temperature increases. Two transient climate change scenarios, called 'weak' and 'strong' climate change are used throughout all fact sheets on climate change impacts to depict the general uncertainty in predicting climate change. These two scenarios are based on IPCC scenarios and adapted to the Alpine region. The two scenarios are composed of statements on global and regional developments of temperature, precipitation and extreme events, including some indication on the spatial and temporal distribution of regional climate change (see Table V). Some of these statements are explained in separate fact sheets. The fact sheet on regional climate models for example visualizes possible patterns of the spatial distributions of temperature- and precipitation-change in Switzerland.

All fact sheets on climate change impacts build on those two scenarios. Statements for both scenarios are visualized on one screen to allow for direct comparison. The likelihood of the various impacts described in the statements are not the same. We decided to indicate the likelihood of different statements in their sequence and wording. More likely impacts are mentioned first and the least likely impacts are mentioned at the end. Additionally, a careful wording was used to indicate the likelihood of an impact. Figure 10 shows the 'scenario statements'

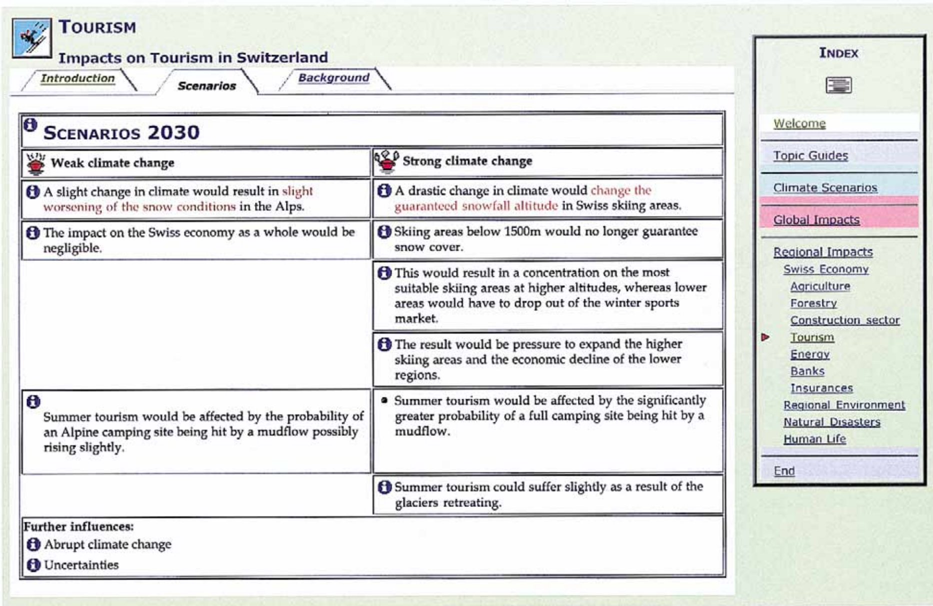


Figure 10. Scenario Statements in the Tourism fact sheet. Statements based on 'weak' and 'strong' climate change scenarios are piled in two columns with corresponding statements in the same row. Differences between corresponding statements are highlighted. Explanatory windows on the influence of abrupt climate changes on tourism and on additional uncertainties are available at the bottom of the screen. A click on a (i) button leads to an explanatory screen for the corresponding statement. Information on both climate change scenarios is also directly available through the (i) button close to 'Scenario Statements 2030'.

screen of the tourism fact sheet that illustrates how the impacts statements were displayed and worded. Besides statements for the two climate change scenarios, additional statements depict possible impacts due to an abrupt climate change and impacts due to non-climate developments.

Uncertainties related to extreme events are depicted with a fact sheet on strong precipitation that indicates that even small changes in mean climate conditions could have a large effect on the frequency of strong precipitation events (see Box 2).

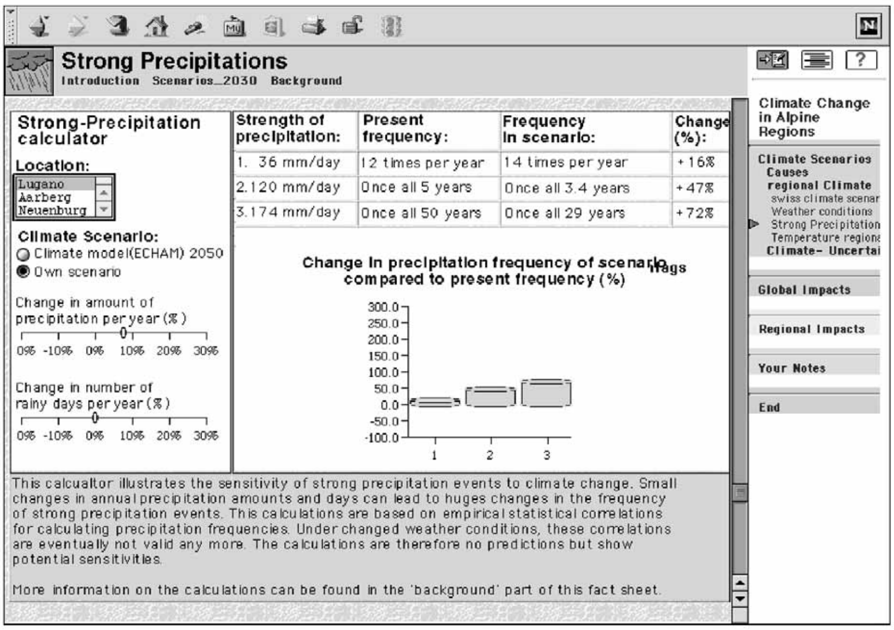
Box 2: 'Strong Precipitation Model'

It is difficult to make plausible scenarios for strong precipitation events because the processes that lead to such events are not well understood. Furthermore, it is already difficult to statistically evaluate the frequency of those rare events in the past. Calculations (by Frei and Schär, 1999) show an increase in the frequency of intense precipitation events over the last 100 years.

Experiments with climate models indicate that strong precipitation events in the Alpine region might be highly sensitive to a climatic change (Frei et al., 1998). We implemented a fact sheet that contains information about the strong precipitation events and their effects as well as a simple interactive statistical model that informs about the sensitivity of such events to climate change.

The model calculates changes in the frequency of different strong precipitation events at a certain location due to changes in two local climate parameters: change in mean annual precipitation and change in the number of rainy days per year. The frequency of heavy precipitation events is then linked to changes of these parameters using the empirical distribution function for daily precipitation at each location (Fowler and Hennessy, 1995). This statistical correlation is used to interpolate the change in frequencies of strong precipitation events for a change in these two parameters.

The figure shows the user-interface of this model. The user can either choose a scenario derived from a downscaled GCM run or make his own scenario. The resulting changes in the frequencies of strong precipitation events are calculated and displayed immediately. The user can choose between three different locations to get an impression of the spatial variability of strong precipitation events. The model indicates that the frequency of stronger events tends to be more sensitive to a climatic change than the frequency of events with less precipitation.



6. Experiences with IMPACTS in Focus Groups

6.1. IA FOCUS GROUPS WITH IMPACTS

The experiences reported here are based on 10 focus groups that were held in the German-speaking part of Switzerland from March to August 1998 (Willi and Dahinden, 1998). 12 additional focus groups were held in the French speaking part of Switzerland. Two different focus group settings were tested that are based on a different framing of the problem: the 'climate change' setting and the 'low-energy society' setting. In both settings, IMPACTS and OPTIONS were used to inform citizens about regional climate change and policy measure to address climate change. Shared features and differences of the two settings are shown in Table VIII.

The main differences were the framing of the problem and the time and sequence of presentation of the two ICITs. In the 'climate change' setting the problem was framed in terms of the risks of a climate change and the policy options that should be pursued to avoid negative climate change impacts. In the 'low-energy society' setting, the discussion started with considering a low-energy society in Switzerland as a vision for a sustainable society. Climate change was then discussed as just one environmental problem that could be addressed by such a policy option.

In the 'Climate change' setting, IMPACTS was used in two sessions and in the 'low-energy society' setting in one session. Each session lasted for around 2.5 hours. The participants worked with IMPACTS for around 1.5 hours per session. The rest of the session-time was used to introduce IMPACTS, to fill out questionnaires and to discuss experiences and results of the work with the tool. After a short introduction, the participants worked with IMPACTS on their own on laptop computers in groups of 2–3 persons. As IMPACTS contains a huge amount of information, some guiding questions were provided that the citizens had to answer with IMPACTS. Apart from those guidelines, the participants were free to explore any part of the information system. The focus group moderators were trained in working with IMPACTS and were given a general guideline for using IMPACTS in focus groups. This allowed them to help the participants in browsing through IMPACTS, if necessary. Towards the end of the session, one person from each subgroup gave a summary of the findings to the plenary.

We will first present and discuss the evaluation of IMPACTS by the focus group participants and by the moderators. Then we will focus on how the citizens reacted to the way IMPACTS conveyed information on uncertainties. We will also discuss shortly the overall evaluation of climate change by the citizens.

6.2. EVALUATION OF IMPACTS AS AN INFORMATION TOOL

The evaluation of IMPACTS is based on three data-sources. First, the citizens had to complete a questionnaire before and after the use of IMPACTS. Secondly, the experiences with IMPACTS were discussed in the focus group and a protocol of

Table VIII

Activities and questions addressed in the IA-focus groups by setting. Italic: name and part of ICIT used

Setting	'Climate change' (6 IA-focus groups conducted)	'Low-energy society' (4 IA-focus groups conducted)
Session 1	Introduction Production of collages	Introduction Production of collages
Session 2	*IMPACTS: Causes-model* (1) What are the pressures leading to climate change? What are the most important factors? (2) Climate futures: Which pictures of the future (scenarios) are distinguished in IMPACTS? Why two different scenarios? (3) Global impacts: Which are possible impacts of climate change on Ocean currents? What global impacts are presented in IMPACTS?	*OPTIONS: Energy model* (1) Which changes are necessary in order to realize a low energy society? (2) In which sectors (traffic, households etc.) do you see a need for action?
Session 3	*IMPACTS: Regional impacts* What are regional impacts of climate change? (Use of IMPACTS according to a selection of questions brought up by participants)	*OPTIONS: Economic model* (1) Under which assumption is the realization of a low energy society rather easy, under which assumptions rather difficult? (2) Which one of these assumptions seems to be more adequate to you? Why? *OPTIONS: Measures* (3) Which of these measures seem to be especially interesting? (4) Which of these measures would you support? Which ones not? Why?
Session 4	*OPTIONS: Measures* (1) Which of these measures seem to be especially interesting? (2) Which of these measures would you support? Which ones not? Why?	*IMPACTS: Cause model* (1) What are the pressures leading to climate change? What are the most important factors?
Session 5	Production of citizen report	Production of citizen report

this discussion was made. Finally, the moderator, the person who kept the minutes and a video camera observed the participants while working with IMPACTS. A more detailed evaluation of the technical aspects will be reported (Büssenschütt et al., in preparation).

6.2.1. *The View of Focus Group Participants*

All in all, the overall reaction to IMPACTS was very positive and most participants liked to work with IMPACTS in the sense that they preferred it to written handouts. Some also wanted to get IMPACTS for their own use at home or proposed to use it in educational settings like in schools.

Qualities of IMPACTS in the view of the citizens:

- Very user friendly.
- Accessible also to people not used to computers.
- Visually attractive.
- The focus on regional impacts rather than global aspects.

Shortcomings of IMPACTS in the view of the citizens:

- Informative but non-directive.
- Too much information.
- Language too technical.

Some citizens were disappointed by the non-directive nature of IMPACTS. They demanded for an overall assessment and for normative statements on climate change in IMPACTS. They wanted IMPACTS to take a clear position: Is climate change a threat or not? The citizens felt somewhat uncomfortable in having to make their own overall assessment.

Many citizens felt overwhelmed by the amount of information in IMPACTS while others stated that they knew already everything:

> ‘The model (IMPACTS) is frenzied. It doesn’t stop – you encounter new questions on and on. It’s infinite’. (Focus group 2, Zurich)

> ‘Everybody already knows about the things I was reading in IMPACTS – even without being concerned with the topic’. (Focus group 3, Sissach)

The two statements provide some insights regarding the range of possible reactions of citizens to IMPACTS. Most of the reactions concerning contents were not as extreme. In our view, IMPACTS conveyed new facts to most of the citizens. But many of these facts are quite logical and no big surprises for the citizens – this is in our view the cause for statements like the second one.

The focus group participants sometimes were not used to selecting information on their own. For those participants, some help in finding information and some guiding questions were provided.

Irrespective of a rather huge effort on our side to keep most of the language in IMPACTS easy to understand for citizens, we did not fully achieve this. Some specific scientific expressions like 'climate-sensitivity' were sometimes hard to translate and difficult to understand. It might be useful to include media and communication/language experts into future efforts to build ICITs.

6.3. PERCEPTION OF UNCERTAINTIES BY CITIZENS

In our view, the most difficult and also most interesting problem was the communication of uncertainties with IMPACTS. Citizens encountered difficulties in dealing with the uncertainties as presented in IMPACTS:

> 'The model (IMPACTS) gives no clear answers. There are speculations and eventualities. We know as much as before'. – 'But it conveys a notion of the complexity of all this stuff'. (Focus group 2, Zurich)
>
> 'The model (IMPACTS) points out the complexity. It is salutary but not helpful'. (Focus Group 2, Zurich)
>
> 'Since the statements on climate change are neither black nor white, they are not taken sufficiently serious'. (Focus group 5, Sissach)
>
> 'I'm scared by the uncertainties in science'. (Focus group 5, Sissach)
>
> 'There are so many scientists. What are they all doing?'
>
> 'If the scientists can't agree, how should we be able to make a statement on climate change'. (Focus group 5, Sissach)

In our view, this lack of an overall assessment in IMPACTS is an important feature of the information tool. It allows making uncertainties explicit and demands citizens to think about their own assessment of climate change based on the facts and uncertainties provided. In the end, this discrimination between facts and uncertainties provided by IMPACTS on one side and preferences and risk assessment by the citizens on the other side is one of the key components of this participatory IA method.

While IMPACTS succeeded in making uncertainties explicit, it did not succeed in informing citizens about the inherent and irreducible nature of many uncertainties. Many citizens were also reluctant to work with scenario-based models. We conclude that it is not sufficient to present only ranges of possibilities but that it is furthermore necessary to discuss the nature of uncertainties (especially inherent uncertainties) with the citizens. As the categorization and treatment of uncertainties is already a difficult task among different scientific disciplines, it is even more difficult to get a shared understanding of uncertainties among scientists and citizens.

We have discussed the citizens' view on uncertainties with the disciplinary scientists within CLEAR. Lively discussions arose on how to communicate different types and sources of uncertainties to citizens. As for now, we can just state that scientists have to be aware of these problems when communicating with laypersons – just providing probability distributions or scenarios is not enough. The formation of a shared understanding of different types of uncertainties might be one of the crucial topics in a process of social learning between the scientific community and society at large.

6.4. CITIZENS' ASSESSMENT OF REGIONAL CLIMATE CHANGE

It is difficult to evaluate the overall effect of IMPACTS on the citizens' assessment of climate change. The dynamics of the group discussion, the background knowledge of the participants and the additional information provided through handouts and other ICITs all affected their assessment.

An important part of the focus group sessions was the production of a 'citizens' report' by the participants. The content of this report was already structured with questions (see Table III). In this report, the citizens had to assess climate change and to produce policy recommendations for Switzerland.

Concerning the question whether climate change is a problem, nine of ten groups concluded that it is a problem now and in the future. On the question what the problem is, participants reacted quite differently. A rising sea level, health problems (asthma, epidemics, allergies) and change in vegetation patterns were regarded as the most serious problems. Monetary concerns were not prominent in their assessment of climate change impacts. The rising demand for energy and corresponding emissions of CO_2 were regarded as the main reasons for climate change. Climate change was expected to come about so fast that humankind and nature will not be able to adapt to it (see Jaeger et al., 1999; Kasemir et al., 2000).

6.5. EVALUATION OF IMPACTS

It was unclear whether the combination of computer tools and citizens in focus groups would work at all when we started. Now, we conclude that the approach is feasible and that citizens were able and willing to work with computer tools in discussion groups. Experiences with computer tools in the context of the ULYSSES project (Dahinden et al., 1999) support this conclusion. The following list give an overview of the evaluation of IMPACTS.

- IMPACTS was accessible to the participants and they liked to work with it.
- The combination of short texts, pictures, animations and simulation models provided a stimulating environment for citizens to explore a large amount of information.
- The quality of the discussion on climate change impacts improved after the use of the model. The model helped participants to structure the topic.
- The participants appreciated that a broad range of impacts was included. It didn't matter to them whether these were monetary or not.

- The message of inherent and irreducible uncertainties was new to most participants. The model succeeded in making these uncertainties explicit. Nevertheless, citizens had problems in understanding the nature of inherent and irreducible uncertainties.
- Participants were reluctant to use scenario-based models. Such models didn't fit with their view of science as an 'exact art' (i.e., speaking truth and certainty to society).
- There was too much information in the tool. Some citizens started to browse through the large amount of information without reading it.

Compared to IA-models like TARGETS, ICAM and IMAGE, the advanced features of the hypermedia navigation system together with the concept of hierarchically organized and structured multimedia fact sheets are a clear advantage for the use in focus groups. This view is also supported by the findings in the ULYSSES focus groups where IA-models were also tested (Dahinden et al., 1999):

> 'The first experiences with those (IMPACTS, OPTIONS) models are rather promising: Participants were able to use the models without a model moderator. This is even true for people who had never worked with a computer. Second, participants liked the well-structured and user-friendly interface. . . . Third, they appreciated that in each model several scenarios and options could be checked, indicating a range of possibilities rather than a single, optimal solution'.

In our view, the following factors proved to be useful for IA-focus groups:

- Hypermedia navigation scheme (hyperlinks, navigation bar, table of contents).
- State-of-the-art user-interface with multimedia elements.
- Availability of explanatory windows.
- Regional perspective on climate change.
- Qualitative and quantitative statements in user language.
- Visualization and explanation of a broad range of possible impacts (also in non-monetary terms).

The task of transforming scientific information into user language is rather demanding. Despite huge efforts from our site to achieve this goal, we did not fully succeed. One possibility to address this problem could be to include an interactive glossary that explains some scientific terms that are difficult to transform. Another would be to involve media people and/or communication specialists in the process.

The most important lesson learned was that multiple scenarios as well as interactive simulation models on possible abrupt climate changes are not sufficient to explain the nature of inherent and irreducible uncertainties to the citizens. Based on the experiences in ULYSSES with TARGETS and ICAM we conclude that citizens have the same problem with probability-based and scenario-based IA-models. An IA-focus group could be used as a microcosm to test new approaches to communicate and discuss the nature of uncertainties in assessing climate change.

We conclude that uncertainty communication should be a key issue in research on participatory IA. Ongoing research on uncertainty, for example under the heading of post-normal science, but also risk communication and the broader IA community underpin the need for such efforts if science intends to engage in a dialogue about climate change with regional stakeholders, in general, and citizens in particular.

7. Conclusions

We stated that citizens are important stakeholders and decision makers because potential impacts of regional climate change are diverse and encompass different topics such as economic impacts, change in the Alpine environment, or health issues. The citizens' framing of the problem, their values and risk attitudes are necessary to judge and compare different potential impacts. A participatory IA of climate change is perceived and studied as a process of social learning involving scientists, citizens and policymakers.

We presented a new approach in participatory IA where informed citizens are assessing regional climate change in deliberative group discussions: IA-focus groups. We proposed 'Interactive Citizens' Information Tools' (ICITs) as a means to produce and present information about facts and their associated uncertainties.

With IMPACTS, we demonstrate the feasibility to implement an ICIT on regional climate change. We concluded that the embedding of the IA project in a larger research project on regional climate change was important in order to implement credible scientific information in IMPACTS.

IMPACTS succeeded in informing citizens about regional climate change without prejudicing an overall assessment on regional climate change. From our evaluation of the focus groups we find that citizens were able and willing to use IMPACTS and that the group discussions improved after the use of IMPACTS.

Although IMPACTS succeeded in making uncertainties explicit, it was not able to inform citizens about the nature of irreducible uncertainties. The formation of a shared understanding of different types of uncertainties might be one of the crucial topics in a process of social learning between the scientific community and society at large. In the final phase of the CLEAR project an educational tool on uncertainties will be added to the CLEAR Information Platform. This tool will discuss the nature and sources of uncertainties in assessing complex problems like climate change. The CLEAR Information Platform empowered citizens to deliberately discuss different policy options.

Many citizens stated that they would like the possibility to work with IMPACTS at home. Others recommended us to use IMPACTS in educational settings. ProClim, an independent organization of the Swiss Academy of Sciences hosts IMPACTS as a thesaurus of Swiss climate change research for a broader audience on the Internet. This indicates that ICITs have a wide potential beyond focus groups. We decided therefore to put IMPACTS on the 'World Wide WWW'. First tests with

IMPACTS in educational settings were promising and we are working on material for teachers to use IMPACTS in schools.

ICITs will have applications in many other fields where scientific knowledge has to be transformed for participatory integrated assessments with non-experts like environmental risk assessments and urban-planning.

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