Dutch National Research Programme on Global Air Pollution and Climate Change

Climate Risk Assessment: Evaluation of Approaches

Synthesis report

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ABSTRACT

Current climate risk assessment practice was evaluated from a user perspective. The goal was to identify areas where climate risk assessment can be improved to better match the cognitive frameworks of its users. Risk assessment is understood as a process connecting knowledge (science) and action (policy) involving a conceptual layer, shaped by scientific understanding of climate risks, and a operational layer, shaped by action oriented stakeholder perspectives.

To map the operational layer we elicited the constructs stakeholders use to assess climate risks. The conceptual layer was mapped by means of a document analysis focussing on what risk dimensions are addressed in present day climate risk assessment studies. We confronted both layers in a workshop with scientists and stakeholders.

Our findings imply that scientists must recognise that uncertainties and value-loadings are integral to the selection and shaping of problems and interpretation of the results as opposed to the traditional situation of 'science speaking truth to power'. The quality of research, and the integrity of scientists, will be assured by accommodating uncertainty and transparency in the debate, which will fully involve the extended peer community.

Crucial to this new approach is that the public now expects disagreement among scientists on complex and contentious issues; the appearance of unanimity only arouses suspicions. The traditional approach, where healthy scientific debate was done in private among consenting scientists and concealed from students and the public, is no longer appropriate.

Research on climate change does not need to be primarily designed around computer models whose outputs are global mean temperatures at some future date. Rather, it can accommodate the public's need for plausibility, focussing on extreme weather events and the regional consequences of the processes of change. Scientists could benefit from an improvement of their skills in communication of results and assessments, and from an enhancement of their awareness of the nature of these new problems and of the conflicts in their role.

1. INTRODUCTION

Within the framework of the Netherlands National Research Program on Global Air Pollution and Climate Change (NRP) a large body of work has been devoted to climate risk assessment. The NRP signalised that, seen form a user-perspective, the expected degree of usefulness of these climate risk assessment studies is often not met satisfactory by the actual results from these studies. Scientific results and policy needs may be better tuned to enhance the fruitful utilization of the research in the societal process of climate risk management.

To address this problem, the research project "Climate Risk Assessment, evaluation of approaches" has been set up. The project has evaluated current climate risk assessment practice starting from a user perspective. The goal was to identify areas where climate risk assessment can be improved to better match the cognitive frameworks of the users (policy and society) of these studies.

In order to achieve this goal, three sub-projects have been formulated:

1. Identification of constructs (risk dimensions) applied by stakeholders to think about climate change;
2. Identification and review of the various conceptual risk approaches that can be distinguished in climate risk assessment studies within and outside the NRP. The project has analysed what risk dimensions have been addressed and has looked at possibilities, limitations, strengths and weaknesses of each approach.
3. Confrontation of supply and demand and validation of findings by means of a workshop.

1.1 The science policy interface

Climate risk assessment is a process that links knowledge (science) and action (policy/society). Assessment comprises the analysis and review of information derived from research for the purpose of helping someone in a position of responsibility to evaluate possible actions or think about a problem. Assessment means assembling, summarising, organising, interpreting, and possibly reconciling pieces of existing knowledge, and communicating them so that they are relevant and helpful to an intelligent but inexpert decision-maker (Parson, 1995).

One way to think about the interface between climate science and policy/society is in terms of the match of *supply* and *demand* of information on climate risks. However, the relation between demand and supply of climate risk assessment is not straightforward:

- First, the science policy interface with regard to climate change in The Netherlands constitutes a rather close network using similar concepts to frame issues for both policy and science. Consequently, demand and supply are hard to distinguish and cannot be fully separated.
- Secondly, scientific information performs a number of social functions. Scientific risk assessment may be used for general policy purposes, for symbolic purposes, for shaping specific policies in advance or for legitimising a policy afterwards. The user does not always know in advance what the function of scientific information will be, since science may always have a function of enlightenment and, therefore, surprise. As scientific information can be considered a collective good, it often has more users than the party who contracts and pays for it, and different users tend to interpret and use scientific information differently.

Consequently, we did not restrict the concept ‘match’ to its economic connotation which refers to market equilibrium between supply and demand, but as much to include all social functions of science including that of enlightenment and surprise. Mismatch may then be found if there is a bias, which prevents science from exercising this classical function. Biases in the information flow can be caused by a lack of plurality and competition of views either at the demand or the supply side.

In accordance with this conceptual starting point, the project has not used an oversimplified distinction between risk approaches held by ‘researchers’ and by ‘policy-makers / stakeholders’. Instead, it distinguished two layers of thought within approaches to climate risk, which are labelled *conceptual* and *operational* respectively. This distinction tries to avoid the normative connotation of distinctions such as scientific-lay knowledge and recognises the possibility of overlapping approaches because of the conceptual power of the policy science interface. It does not deny, however, that the conceptual layer of thought about climate change risks has mainly been developed in the scientific risk literature, while the operational level primarily exists with respect to human action. Thus, by conceptual layer we refer to the knowledge-oriented dimensions that have initially been brought up by scientific risk experts in order to define and distinguish between specific risk characteristics. Examples of what is part of this conceptual layer are the time horizon of impacts to occur or the mapping of causal relations that govern the dynamics of the climate system and its response to anthropogenic forcing. By operational layer we refer to constructs and categories used by people to define and distinguish between climate risks from an action oriented perspective. Also here, time frames are important, but the meaning and connotations of the concept time frame are in many ways distinct from the use of the concept in climate science. Time frames may relate to legal obligations provided by international agreements, such as the Kyoto protocol, or to political and financial constraints in a country.

Mapping the differences and similarities between the two layers of thought meets with difficulties that follow from the fact that, although science and policy making constitute quite different cultures in many respects, in the case of climate they are closely intertwined.

1.2 Outline of report

Chapter 2 outlines the method by which we elicited constructs used by stakeholders to assess climate risks. These constructs represent the operational layer of climate risk assessment. The chapter also presents the findings and our interpretation of these findings in terms of criteria and implications for usable risk assessment information.

Chapter 3 presents the findings of our document analysis of climate risk assessment studies, constituting the conceptual layer of climate risk assessment. It analyses risk dimensions and risk concepts applied in these studies, discusses strengths and weaknesses of the different approaches that can be identified and addresses to what extent the constructs stakeholders use to assess climate change have been addressed in these studies.

In chapter 4 we summarise the findings of a workshop in which we confronted the operational and conceptual layers. The workshop was also used to validate findings of our analysis of both layers.

Chapter 5 integrates the results and presents, discusses and the conclusions of the project and summarises the findings in terms of its implications for the science policy interface.

2. THE OPERATIONAL LAYER OF CLIMATE RISK APPROACHES

2.1 Method

To map the operational layer of climate risk approaches, we have applied a special type of non-steering open interviews, known as *repertory grid* analysis (Dunn and Ginsberg, 1986; Dunn, Pavlak and Roberts, 1988, Dunn, 2000), to elicit from stakeholders the constructs they use to think about climate risks. The repertory grid analysis enabled us to elicit subjectively meaningful constructs employed by respondents to interpret the risks of anthropogenic climate change. Grid-methodology avoids asking specific questions to the interviewees. Instead, the interviewer uses a set of cards, containing the so-called elements that determine the focus of the interview. The project has used two sets of elements, one set covering the spectrum of impacts of climate change including impacts of climate policy, and one set covering the spectrum of policy options to respond to climate change. As a stimulus, the respondent was presented three cards (elements) randomly drawn from the set and was then asked to indicate how two of these three elements were alike and different from the third regarding an aspects that he or she deemed relevant for the climate debate. The respondents answer is what repertory grid analysis calls a *construct*. For each respondent, the procedure was repeated until the respondent did not produce new constructs. Then the respondent was asked to select the three most important constructs from the list he or she had generated. For these three constructs the respondent was asked to score the extent to which this construct applied to each of the elements from the set. For validation purposes, a limited number of open interview questions was used additionally. In total we interviewed 27 stakeholders. Stakeholders were selected using snowball-sampling techniques. The interviewees can be divided into the following categories: business 10; environmental NGOs 5, research managers 5, Ministries 7. About equally spread over these categories, sixteen interviewees can be considered as being rather closely involved in the climate change policy-making or research network, eleven can be considered as standing rather outside this network. All together, the 27 respondents generated 105 constructs with regard to climate impacts and 130 constructs with regard to interventions. By means of a qualitative analysis constructs with more or less the same meaning were grouped to make the size of the set manageable while maintaining the major part of the nuances in meaning. This led us to a set of 14 'unique' constructs regarding climate impacts and 17 'unique' constructs with regard to interventions.

2.2 Findings

We have analysed the results using the HOMALS algorithm for optimal scaling. In HOMALS categories of each variable are quantified in such a way that persons within the same category are placed close together whereas persons in different categories are placed far apart. By dividing persons into homogeneous subgroups over all the variables, HOMALS can often summarise the relationship between two or more nominal variables with a single two-dimensional plot. The HOMALS analysis thus produces the major dimensions or criteria that respondents use to evaluate information about climate change risks. It cannot, however, interpret these meta-dimensions. Therefore, next to statistical analysis, we have interpreted the meta-dimensions found with HOMALS by tracing back the constructs that produced these dimensions. For a detailed description of the method and how we applied it in this project we refer to working document 1 and the appendix to working document 1 (De Boer *et al.*, 2000)

Table 1. Unique constructs with regard to effects of climate change, elicited from the respondents (See Working Document 1: De Boer *et al.*, 2000).

1. Ecology-economy (effects can have impact on nature or on the economy and policies)
2. Negative-positive
3. Small scale – large scale
4. Certain effects – uncertain effects
5. Geographical site (effects can have impact on different countries/places).
6. Impact (this construct is broad and comprises issues like importance and degree of harmfulness)
7. Controllability (we can influence some of the effects, others are more autonomous)
8. Nature of effect (this construct refers to the 'objects' that are effected, for example land-use or health)
9. Climate related – not climate related (some of the effects are considered to be caused by other factors than climate change)
10. Irreversible – reversible
11. Direct – indirect (a raise in temperature is considered as a direct effect, changes in e.g. agricultural production as indirect)
12. Incidents-structural (some of the effects are processes of gradual change, some appear once and a while).
13. Fast –slow effects
14. Equity (some of the effects relate to issues with respect to the distribution of wealth, others not).

Table 2. Unique constructs with regard policy options to deal with climate change as elicited from the respondents (See Working Document 1: De Boer *et al.*, 2000).

1. Adaptation – mitigation
2. (political and social) feasibility
3. implementation
4. technical – non technical solutions
5. effectiveness
6. efficiency
7. legitimacy
8. no regret – solely aimed at climate change
9. degree of internalisation
10. using standards (criteria) setting /not using this
11. time/term
12. geographical site
13. scale
14. (negative) side effects
15. (indirect) instrument – (direct) measure/policy target
16. general – specific
17. target group

One might have expected the grid analysis to show a discriminative pattern, distinguishing clusters of respondents employing sets of constructs to interpret the risks of anthropogenic climate change that are different from the sets of constructs used by respondents placed in other clusters. However, this turned out to be not the case. The data allow for two possible and complementary interpretations. The first is that the grid-analysis has only produced fragments of risk approaches and that the patterns are too diffuse to draw conclusions in this respect. The second interpretation indicates that, the interviewees employ roughly the same set of constructs to interpret climate risks. In other words: there is a great deal of consensus about what the important constructs are to take into account when assessing the risks of climate change. The respondents share the conceptual image that global climate change may have impacts on nature and on society, that impacts may be destructive or even positive and that they may or may not be controllable. Controllability clearly showed up as a key construct in the risk-approach as put forward by the respondents. Within this frame, there is –not surprisingly- divergence of opinion as to whether climate risks are serious and (un)certain, as well as to whether specific impacts can be attributed to anthropogenic climate change. Also the weighting of the different constructs may diverge across the respondents.

In conclusion, the interviews and the HOMALS-analysis did not produce a clear differentiation between risk approaches at the demand side. It seems as if stakeholders in The Netherlands more or less share an approach to climate change risks. This approach is not necessarily similar to scientific approaches to risk. The construct *controllability* is at the heart of the approach.

2.2.1 Possibilities for human action

The respondents employed in total 17 'unique' constructs with regard to controlling the climate change problem by interventions (see table 2). As with respect to the dimensions of impacts, not all dimensions/criteria are equally important. The HOMALS analysis showed that the most important construct is Adaptation – Mitigation. It's not the extremes but the middle of this dimension that is preferred by the respondents. Adaptation measures are not considered as real solutions whereas more drastic options are often perceived as not feasible or hard to implement. Furthermore, the interviewees showed a remarkable preference for what they consider *no regret* options. Yet, according to most interviewees no regret should specifically address the climate problem. Respondents that consider the climate system as robust seem to prefer no regret options that serve various purposes at the same time.

In addition to these findings, the answers to the open questions suggest that the respondents see governments and enterprises as the crucial actors with respect to dealing with climate change. The respondents consider citizens less important. This may be a bias due to the composition of our sample of stakeholders, which did not include citizens. Other actors that are considered important are Developing Countries and science. The views respondents hold about their own institution roughly matches the view the respondents have on each other. Enterprises agree that they can take action, however not only for reasons of climate change but mainly for reasons of cost reduction and depletion of energy sources. Environmental groups are not mentioned by others as important actors, but some respondents of the environmental movement feel that they can play a role with respect to raising the awareness and influence the decision making process.

In conclusion, the interventions related constructs and additional information from the interviews somewhat sharpens our understanding of the construct of controllability. On the one hand, interventions are evaluated as to whether they really contribute to mitigating climate change or preventing the climate from changing (further or rapidly). On the other hand, interventions are evaluated in the context of other issues. The nesting in this broader context of issues, be it overall cost-effectiveness or social support, is considered equally important, although for different reasons.

2.2.2 Criteria for usable risk assessment information

The dimensions, which come out of the HOMALS analysis may be interpreted as criteria that the interviewees use to evaluate information on climate risk. For methodological reasons we did not directly ask respondents to specify their criteria for information needs. Therefore we base our findings on our interpretation as analysts.

With regard to impact related constructs, the dimensions that turned out to dominate stakeholders' discourse were:

1) Effects on nature versus effects on society.

   This dimension is found to be correlated to controllability en plausibility. Controllability relates to opportunities to reduce risks by human intervention, whereas plausibility to some sort of causality, especially reducibility or attributebility of certain phenomena to anthropogenic climate change.

2) Substantial destructive versus small and maybe beneficial impacts.

   This dimension is found to be correlated to (un)certainty.

The constructs related to both dimensions show quite some overlap.

The most significant finding with respect to usability of climate risk assessment is that scientific (un)certainty is not found to be a dominant or independent dimension. In other words: when stakeholders evaluate climate risks, the scientific uncertainties are not an important criterion to judge the relevance of the information. This implies that stakeholder support for climate policy does not require elimination of scientific uncertainty. Whereas from the perspective and interest of researchers uncertainty is considered a most valid argument to promote scientific research, for the potential users this consideration does not stand apart from relevance as related to substance. This might look trivial, but it is not, given the hausse in literature on 'dealing with uncertainty'. Thus, respondents don't seem to care very much about as to whether the Dutch climate may get milder or colder, but possible irreversible damage to coral reefs is considered relevant even if this effect is very uncertain. Obviously there can be argument about this specific example but the point is that uncertainty must not be considered equivalent to relevance. So, the degree of (un)certainty does not as such shape risk assessment information needs, as uncertainty is not necessarily an indicator of relevance.

The second observation relates to the variables that constitute relevance. The most significant finding in this regard is the one on controllability and the tension between controllability and the seriousness of impacts. Potential users of climate risk assessments seem to be interested in information on developments of the climate system and climate change impacts that are at the same time destructive and controllable. In this respect, plausibility is important. This construct could have implications for research methodology but this is yet to be investigated. Plausibility is related to controllability in two ways: First, impacts or events can be causally related to human activities. Secondly, specific human action is likely to reduce or mitigate the specific events or impacts.

In conclusion stakeholders appear to ask for information on risk seriousness, on controllability of risk (either in The Netherlands or abroad) and on causality in a dual respect, i.e. on anthropogenic causes and on the effectiveness of human action.

The observations with respect to information needs that can be derived from the analysis on intervention related constructs are in line with the observations above as they further unfold the meanings attached to the concept of controllability. We found the following dimensions to dominate stakeholders' discourse in this respect:

1) Adaptation versus pro-action,

2) Options that are considered specifically climate change related versus options that are not specifically climate change related.

The HOMALS analysis shows that these dimensions are not mutually independent. In their evaluation of interventions, stakeholders seem to use two sets of criteria. On the one hand, an option or intervention should be prudent in that it affects (reduces or mitigates) climate change. On the other hand, an option or intervention is evaluated in and should be nested in a broader context. This latter criterion implicates that an option may either contribute to solving other (social or environmental) issues as well and / or must match generally accepted standards. Thus, a national Disaster Fund is not considered a contribution to mitigating the climate problem, but is at the same time not controversial. Options such as changing values with respect to mobility and compulsory birth control are considered real contributions to addressing climate change, but for various reasons they are not considered feasible or desirable after all. The conclusion is not very surprising: Potential users of climate risk assessments in The Netherlands have a preference for interventions that are effective and not very controversial. However, if these observations are translated into criteria for usable information, they deviate in some respects from common practice.

From the constructs respondents use to differentiate amongst options we inferred the following notions regarding information needs:

First of all, information on mitigation options is preferred over information on adaptation options.

Secondly, stakeholders want to know as to whether interventions or options are effective in addressing the climate change issue. Aspects related to this criterion include

- measures should affect causes and not only effects,
- effects of interventions last / are not temporary,
- no window-dressing.

Thirdly, stakeholders want to know about the impacts of interventions on other fields including their own (organisation or business) and they want to evaluate the benefits of interventions in the context of other fields and generally accepted norms. An immediate consequence of this requirement is that statements such as 'solution is technically possible' is not considered very relevant. In informing about feasibility and desirability of interventions, a broad array of aspects might be taken into account, such as cultural and emotional, political, system change, markets, social and demographic. Obviously, this is not meant as if stakeholders want information on (all) these aspects from risk assessments, but the relevance of climate risk assessments is considered in this broader context.

Fourthly, some additional criteria on the relevance of information on interventions are worth mentioning:

- as to whether the effectiveness of policies can be measured,
- the ethicality of the intervention,
- as to whether the intervention increases the knowledge of actors.

In conclusion, criteria elicited from potential users to evaluate the relevance of climate risk assessments relate to seriousness of risk, controllability and plausibility. Controllability includes criteria labelled as prudence (effectiveness in addressing the climate issue) and nesting (context of other issues). With respect to nesting, a wide range of aspects is taken into account. Additional criteria could relate to monitoring policy effectiveness, ethicality of intervention and increasing actors' knowledge.

3. THE CONCEPTUAL LAYER OF RISK APPROACHES

In sub-project 2 we have analysed a number of climate risk assessment studies and have mapped what concepts of risk have been used and what risk dimensions have been addressed in each of these studies. We also comment on possibilities, limitations, strengths and weaknesses of each study.

The key-research questions addressed in this phase of the project were:

1. What approaches to risk on the conceptual level can be identified in climate risk assessment within and outside the NRP?
2. What dimensions of risk have been taken into account?
3. What are possibilities, limitations, strengths and weaknesses of each of these approaches?

To address these research questions we have formulated an analytical framework and a corresponding set of sub-questions that we applied to each individual risk assessment study. The analytical framework and the results are presented in a separate working paper (Van der Sluijs, 2000). The sub-questions used in our document analysis are:

a. What is the purpose of the study?
b. What is the spatial scale of the study? (global, regional, local);
c. What is the temporal scale of the study? (Time horizon, time step, base year etc.);
d. What stages of the causal chain are covered by this study/approach?
e. What risk-concepts have been used in the study?
f. What risk dimensions have been addressed in the study?

For question f the risk dimensions known from the risk literature as summarized by Vlek and Keren (1986) have been used as a starting point.

3.1 Dimensions underlying risk evaluation

Risk research has shown that people consider a number of dimensions when they judge risks. Based on empirical and theoretical work on a large variety of risks, Vlek (1996) presents a list of basic dimensions underlying the perceived riskiness of an activity or situation (table 3).

Table 3 Basic dimensions underlying evaluation of risk by stakeholders

1. Potential degree of harm or fatality;
2. Physical extent of damage (area affected);
3. Social extent of damage (number of people involved);
4. Time distribution of damage (immediate and/or delayed effects;
5. Probability of undesired consequence;
6. Controllability (by self or trusted expert) of consequences;
7. Experience with, familiarity, imaginability of consequences;
8. Voluntariness of exposure (freedom of choice);
9. Clarity, importance of expected benefits;
10. Social distribution of risks and benefits;
11. Harmful intentionality.

Dimensions 1-4 in table 3 provide specifications of undesired consequences. Dimensions 5-7 qualify the probability. Dimensions 8-11 are additional dimensions that influence perceived riskiness.

In subproject I of our research project we have elicited constructs with regard to effects of climate change used by the respondents. These constructs were grouped into 14 unique constructs, which are listed in table 1 in section 2. We have combined the risk-dimensions from table 3 with the risk constructs from table 1.

The risk dimensions (Table 3) are understood as "basic dimensions underlying the perceived riskiness of an activity or situation" (Vlek, 1996). The risk constructs elicited in our project (Table 1) result from the answers to the question "how are two of these effects alike and different from the third?" for randomly drawn triads of conceivable effects of climate change. Consequently, the constructs are in general formulated bipolar whereas the risk dimensions are not formulated bipolar. For some of the constructs, the correspondence to one of the risk dimensions is straightforward and obvious. In other cases we went back to the list of original constructs that were grouped under to form the unique constructs (see Appendix 1 of working document I) to decide to what risk dimension that construct corresponds or whether that construct should be added as a additional dimension. Our analysis led us to add five risk dimensions to the original list:

- Ecological extent of damage
- Impact sector
- Attributability
- Reversibility
- Primariness of effect

We will discuss each of these dimensions and will classify them as either providing a specifications of *undesired consequences* or as providing a qualification of the *probability or plausibility*.

Ecological extent of damage: One could argue that ecological extent of damage is an aspect of the risk dimension "physical extent of damage". However, in the case of climate change, the ecological consequences play an important role in the debate. The possibility of massive changes in vegetation patterns and loss of biodiversity that may occur if climate zones shift, has made the protection of ecosystems and conservation of biodiversity important issues. Article 2 of the United Nations Framework Convention on Climate Change (UNFCCC) stresses that the goal of the convention, stabilization of greenhouse gas concentrations, "*should be achieved within a time frame sufficient to allow ecosystems to adapt naturally to climate change*". The specific attention given to protection of ecosystems in international climate policy made us decide to include ecological extent of damage as a separate dimension for the purpose of our analysis. Ecological extent of damage provides a specification of undesired consequences.

Impact sector: One of the unique constructs from the list provided in *Working Document I* was named 'nature of the effect'. Going back to the original constructs that were grouped under this heading (appendix 1 of working document I) this construct seems to be related to the question in what sector the impacts occur: health, agricultural production, land use, employment, wellbeing etc. It is a specification of "undesired consequence" but does not directly correspond to one of four dimensions (number 1-4 in table 3) that specify consequences. Impact sector is not the same as the physical extent of damage, which is more related to the area affected. We therefore decided to add a dimension named "Impact sector".

Attributability: The respondents distinguished between effects that were obviously caused by climate change and effects that could be caused by climate change but could have other causes too. The question whether observed effects of climate change can be attributed to human actions that theoretically could have caused them, has played a key role in the climate debate. Even the question whether the observed warming of about a half degree since the beginning of the industrial revolution is caused by human action or not has been subject to a major scientific debate. The IPCC Second Assessment Report (Houghton *et al*., 1995) has been seen as a breakthrough in this sense with as one of it's key findings "the balance of evidence suggests a discernible human influence on the climate". Attributability is a qualification of the probability or plausibilty. It does not correspond with one of the dimensions in table 3. We therefore decided to add it as a additional dimension in our study.

Reversibility: In the original work on risk dimensions by Vlek and colleagues, "reversibility" was one of the aspects of risk that constituted the dimension "controllability of consequences". However, in the case of climate change reversibility not only relates to controllability and the extent to which humans can reverse or undo negative consequences of their actions, but also to whether nature can reverse the effects. Climate change differs from many other risks in that it may induce state-changes in the global natural (climate) system. For instance, research has shown that the possible shut-down of the thermo-haline circulation in the ocean is likely to exhibit hystereses which means that if warming exceeds a given threshold, the circulation may shut down whereas if after such a shut down cooling would occur, the cooling has to go till far below that threshold before the ocean circulation switches back to its original regime (ref: Rahmstorf, 1995). Reversibility here provides a specification of undesired consequences.

Directness of effect: Looking back at the original list of constructs (Appendix 1 of Working document 1), the construct "Direct-indirect" has to do with the order of effects (whether an effect is primary, secondary, tertiary etc.). The more intermediate steps there are in the causal chain between a cause and an effect, the lower the directness of the effect is. This dimension differs from attributability which is related to multi-causality of a given effect. The directness is a qualification of probability or plausibility.

Four of the risk-dimensions known from the literature do not correspond to any of the constructs generated by our respondents. These are: *experience with, familiarity, imaginability of consequences*; *voluntariness of exposure (freedom of choice)*; *clarity of* *expected benefits*; and *harmful intentionality*. The first one, imaginability is somewhat related to the *plausibility*-dimension we found from the homals analysis. The other dimensions were not mentioned or implied by our respondents. Possible explanations for this may be that these dimensions are not relevant for the climate issue or they do not play a role in the climate debate. Although these dimensions have not been generated as constructs by our respondents, they may have been addressed in climate risk assessment studies. For the purpose of our analysis we therefore left them on our list. All together this leads to a list of 16 risk-dimensions of which we have investigated whether these have been addressed by current climate risk assessment studies.

Table 4 List of dimensions that may be addressed in climate risk assessment

	Dimension
Dimensions that specify and/or qualify the nature and size of undesired consequences	1. Potential degree of harm or fatality;
	2. Physical extent of damage (area affected);
	3. Social extent of damage (number of people involved);
	4. Ecological extent of damage
	5. Time distribution of damage (immediate and/or delayed effects;
	6. Reversibility
	7. Impact sector
Dimensions that qualify the probability or plausibility of undesired consequences	8. Probability of undesired consequence;
	9. Controllability (by self or trusted expert) of consequences;
	10. Experience with, familiarity, imaginability of consequences;
	11. Attributability
	12. Directness of effect
Other dimensions that underlie perceived riskiness	13. Voluntariness of exposure (freedom of choice);
	14. Clarity, importance of expected benefits;
	15.Social distribution of risks and benefits;
	16.Harmful intentionality.

3.2 Climate risk assessment studies

Our sample of climate risk assessment studies has been chosen in such a way that a large variety of approaches is covered. We have deliberately included innovative approaches in our sample, making our sample broader than it would have been if we had taken a random sample of risk studies. We have grouped the climate risk assessment studies into five categories:

1. The IPCC Second Assessment report
2. Probabilistic approaches
3. Extreme events, non linear feedbacks and surprise
4. Integrated Assessment Models
5. Decision analytic approaches

In the following we will briefly elaborate on these groups.

1. The IPCC Second Assessment report

The Second Assessment Report (SAR) of the Intergovernmental Panel on Climate Change (IPCC) is the most widely used and most authoritative risk assessment of anthropogenic climate change that was available when we carried out this part of the study (Houghton *et al.*, 1995; Watson *et al.*, 1995; Bruce *et al.*, 1995). (During the finalisation of this project the SAR was superseded by the Third Assessment Report (TAR)) The IPCC aims to assess and synthesise all available published research on anthropogenic climate change. The SAR comprises three reports, each of them being produced by one of the three working groups. The working group I report deals with the scientific state of the art of the climate issue. The working group II report deals with the impacts of climate change and the options to cope with climate change. The working group III report deals with the socio-economical aspects of climate change. We have included all three reports in our document analysis:

2. Probabilistic approaches

The IPCC-assessments do not quantify probabilities of undesired consequences of climate change. We have included two key examples of conceptually different assessment studies, which explicitly have addressed the quantification of probabilities.

- Delphic Monte Carlo, using subjective probability to assess risk (Titus and V. Narayanan, 1996);

- Probabilities of Climatic Change (Fransen and Reuvekamp, 1995).

3. Extreme events, non linear feedbacks and surprise

Extreme events, non linear feedbacks and surprise are aspects of climate risks which are hard to tackle in risk assessment. In main stream assessments such as the IPCC studies and integrated modelling studies these aspects are poorly represented because it is hardly possible to quantify these aspects, there are many unknowns and there is no scientific consensus on these aspects. We have included some key examples of climate risk assessment studies that explicitly have tried to address these aspects of climate risk. These studies cope with:

- Extreme weather events and climate change (Daamen *et al.*, 1992);
- Climate Change and Malaria Risk (Martens *et al.*, 1994);
- Non-linear feedbacks (*Van Ham et al.*, 1995);
- Surprise scenarios (Kates *et al.*, 1996; Schneider *et al.*, 1998).

4. Integrated Assessment Models

Integrated assessment models form a fourth important category. In these computer simulation models, knowledge from many different disciplines is combined in an analytical computational framework to analyze the problem at hand in an integrated fashion. IAMs are mainly used for scenario analysis and evaluation of policy alternatives. In our sample we have included the following models:

- IMAGE 2 (Alcamo, 1994; Alcamo *et al.*, 1998);
- TARGETS (Rotmans *et al.*, 1994; Rotmans and De Vries, 1997);
- DIALOGUE (KEMA, 1997; Visser *et al.*, 1997);
- ICAM (Dowlatabadi, H. and Morgan, 1993; Casman *et al.*, 1999).

5. Decision analytic approaches

A fifth category is formed by approaches that directly address the issue of policy strategies and include methods of risk assessment therein. Although not all of the approaches we include under this header are strictly spoken methods of decision analysis, we group them together because they all address policy strategies to cope with climate risk.

- Hedging (Collingridge, 1983; Ybema, and Vos, 1995; Ybema, 1996; Ybema *et al.*, 1998)
- Multicriteria decision analysis (Van Lenthe *et al.*, 1997)
- Policy options project (Hisschemoller *et al.*, 1995)

3.3.Possibilities and limitations of the various approaches

Our findings for each study are documented in detail in working document 2 (Van der Sluijs, 2000).

This section summarizes our finding regarding the question: what are possibilities, limitations, strengths, and weaknesses of the risk approaches used in these studies?

We will discuss our findings per group of studies. The groups were:

1. The IPCC Second Assessment report
2. Probabilistic approaches
3. Extreme events, non linear feedbacks and surprise
4. Integrated Assessment Models
5. Decision analytic approaches

ad. 1. The IPCC Second Assessment report

The most salient strong points of IPCC assessments are:

- It presents widely supported consensus view based on thorough review and synthesis of state of the art knowledge on climate change;
- It is based on a open multi-party process;
- Reports undergo a extensive peer review;
- NGO's, industry and government representatives take part in peer review process. This increases the policy relevance of the assessment;
- It is embedded in the United Nations;
- The involvement of government representatives in the drafting of policy-making summaries increases the commitment of governments to the findings of the assessment.

An additional strong point specific to the risk approach taken in the IPCC 1995 WG-II assessment is that assessment of risk by mapping sensitivity, adaptability and resulting vulnerability of systems to climate change provides options for risk-reduction without the need to quantify expected regional climate change, to know probabilities or to reduce uncertainties.

The most salient weak points of the IPCC approach are:

- The consensus building process tends to lead to strategic treatment of low probability high impact events (Patt, 1997): those issues on which no consensus can be achieved are under-addressed or ignored whereas such issues may well be policy relevant;
- It cannot cope well with dissent;
- Insufficient utilization of minority interpretations of the science makes assessment biased;

A specific weak point in the approach taken by the IPCC 1995 WG-III assessment is that the monetarization of damage is highly controversial. It has been criticized for oversimplifying the multidimensional human values space to a one dimensional Dollar dimension. Resulting damage figures critically depend on value laden assumptions such as assumed discount rate, and the use of the controversial value laden metrics such as "Value Of a Statistical life" and "Willingness To Pay"

Ad 2. Probabilistic approaches

The approach used in the Titus and Narayanan (1996) study on the risks of sea level rise is known as Delphic Monte Carlo. A strong point of this approach is that it has the potential to make use of all available knowledge, including the views of skeptics; the opinions of those who study ice cores, fossils and other empirical evidence and the insights of climate modellers, which may be as useful as the model results themselves.

The application of Delphi-methods for the drafting of probability distribution functions of model input and model parameters for Monte Carlo Analysis, brings several important methodological difficulties which may limit its usefulness if not coped well with. First, the fraction of experts holding a given view is not proportional to the probability of that view being correct. Second, one may safely average estimates of model parameters, but if the expert's models were incommensurate, one may not average models. Third, if differences in expert opinion are unresolvable, weighing and combining the individual estimates of distributions is only valid if weighted with competence of the experts regarding making the estimate. There is no good way to measure the competence. In practice, the opinions are weighted equally, although sometimes self-rating is used to obtain a weight-factor for the experts competence. Fourth, the results are sensitive to the selection of the experts whose estimates are gathered. Fifth, experts tend to be systematically overconfident about their ability to make predictions, leading to a possible systematic underestimation of the uncertainty.

Although subjective probability is an imperfect substitute for established knowledge and despite the problems of aggregation of expert judgement, if nothing better is available it is better to use subjective probability distributions than deterministic point-values so that one has at least a first approximation of the uncertainty.

A strong point of the Fransen and Reuvekamp approach to assess probabilities of climate change is that it provides a simple, resource extensive way to combine existing knowledge to arrive at a quantified probability estimate for climate change. It is flexible in that it can easily accommodate new insights from the science.

The most salient weak points of this approach are the following:

- The validity of the method depends on the validity of the assumption that each parameter is normally distributed around its mean value.
- The method is over-simplistic which makes it doubtful whether it can yield reliable results. For screening purposes it can be useful as a first approximation of probabilities.

Ad 3. Extreme events, non linear feedbacks and surprise

This group of studies are partial assessments focussing on specific areas that tend to be underaddressed by major assessment studies such as the IPCC reports and Integrated Assessment Models. In that sense the studies are complementary. However, the partial nature of these studies limits their usefulness. A more integrated approach to non linear feedback and surprise would be desirable.

Ad 4. Integrated Assessment Models

IAMs try to simulate the entire causal chain of climate change. The major innovative characteristic of IAMs, which has made it an essential tool in Climate Risk Assessment has been its capacity to dynamically include feedback loops between different stages of the causal chain. There is no other means of integration of insights into complex interlinked cause-effect relationships from multiple disciplines with that capacity.

However, knowledge and understanding of the modelled causal chain of climate change is incomplete and characterized by large uncertainties and limits to predictability. At each stage of the causal chain there are both potentially reducible and probably irreducible uncertainties that affect the estimates of future states of key variables and the future behaviour of system constituents. For a comprehensive review of this issue we refer to Van der Sluijs, 1997. The IAMs currently available do not really integrate the entire causal chain, nor do IAMs take dynamically into account all feedbacks and linkages between the different stages of the causal chain.

The use of a mathematical modelling approach is limited to those parts of the problem that can be quantified and modelled. Consequently IAM-assessments exclude the unmodellable and do not utilize qualitative information. IAM is therefore not a complete IA methodology, it is one set of analytical tools for integration to be used in conjunction with other methods of integration in a broader participatory assessment process.

IAMs are heuristic tools, not truth machines that can predict the future. IAMs are capable of testing sensitivity, of answering 'what if' questions, of ranking policy options, of assessing the relative importance of uncertainties, of identifying research priorities and of providing insights that cannot easily be derived from the individual natural or social science component models that have been developed in the past.

Two of the IAMs studied here have incorporated innovative ways to cope with multiple interpretations of the science. TARGETS for this purpose applied a ideal typical approach (from Cultural Theory) to include different views and value-orientations. TARGETS has been path-breaking in the sense that it acknowledges the possibility of multiple problem structures - both at the level of causal mechanisms behind the problem and on the level of preferences and values - and in that it recognizes the legitimacy of different perspectives on the science. On the other hand this method has a shortcoming in that it restricts the problem structuring to three different static problem definitions in terms of pre-defined ideal-typical categories. By doing so, TARGETS hampers the integration of differing perspectives and differing value positions into new ways of looking at the problem.

The way DIALOGUE deals with expert disagreement is also innovative in the field. Rather than picking one main-stream mono-disciplinary sub-model for each step in the causal chain - as most other IAMs do- Dialogue uses multiple models for each step (for instance, three different carbon cycle models, five different GCM model-outcomes, etc.), representing the major part of the spectrum of expert opinion in each discipline. Dialogue is set up in such a way that it facilitates the inclusion of new alternative models in each step, thereby accommodating a broader range of problem representations and providing much more flexibility with regard to problem structuring than other IAMs do. Weak points of DIALOGUE are that all the sub-models are deterministic and feedbacks between the modeled subsystems are not fully taken into account. So, although expert disagreement has better been taken into account than any of the other models do, other types and sources of uncertainty have not been systematically addressed.

Ad 5. Decision analytic approaches

The most salient strong points of the decision analytic approaches are:

- can deal with uncertainty and incompleteness in an explicit manner
- allows for a policy-oriented problem representation at a high level of aggregation that corresponds to the general level of many policy questions
- deals explicitly with values and preferences

A weak point is that some of the approaches such as hedging are based on the assumption that uncertainty will decrease over time. Unfortunately for the climate problem this is not likely to be the case (Van der Sluijs, 1997). These approaches can not handle well the irreducible uncertainties and complexities that characterize the climate problem.

The decision analytic approaches need the other approaches to build upon and are hence complementary. On the other hand the decision analytic approach is strong is structuring the problem at hand, which can guide the other approaches to focus on the most policy relevant questions.

3.4 Findings

The mayor overall findings of our analysis is subproject 2 are the following:

- Most studies are at a global spatial scale. A few studies assess the problem at continental and regional levels. Assessments of climate risks at a local level are hardly available and only partially possible because uncertainty in climate projections increase exponentially with decreasing scale level. Assessment of vulnerability to a wide range of regional climate change scenarios is possible at any spatial scale and seems the best way to proceed with climate risk assessment on regional and local scales.

- With regard to temporal scale a century time scale with the year 2100 as typical time horizon dominates the assessment studies. Only a few studies consider effects on longer time scales. Assessment of effects of climate change with a potential very large impact, such as the possible collapse of the West Antarctic ice sheet, require the consideration of longer time scales.

- With regard to the stages of the causal chain taken into account in the risk assessment studies, it strikes that the major focus of the studies is on the middle of the chain, namely on the choice of technologies and practices, emissions and the changes in the environment (greenhouse gas concentrations, temperature change, sea level rise). Relatively little attention is given to deeper causes of climate change (*culture and values*, and *demand for goods and services*) and to *exposure* (the causal connections between a change in the environment and the damage that results from it and the key factors that influence this relation).

- The majority of the assessment studies use a risk concept where effects are specified and often quantified but the probability of the effect is not quantified nor is the plausibility expressed in any metric. One small group of studies (we need to say here that we included those studies because of their innovative character in this respect) provide quantified estimates of probabilities: the Delphic Monte Carlo study of sea level rise by Titus and Narayanan, the probabilities of climate change study by Fransen and Reuvekamp and the ICAM model. In fact, the ICAM model uses the Delphic Monte Carlo approach in an integrated assessment model.

- It strikes that none of the Integrated Assessment Models constitutes a multi-party or participatory assessment (see also: Van der Sluijs, forthcoming).

- With regard to risk dimensions we had distinguished three groups (table 4): (1) dimensions that specify and or qualify the nature and size of undesired consequences, (2) dimensions that qualify the probability and plausibility of undesired effects and (3) other dimensions that underlie perceived riskiness. Our analysis shows that the most extensively addressed dimensions in climate risk assessment are in the first group and the least addressed dimension are in the second and third group. The significantly lower attention to dimensions related to probability and plausibility as compared to the dimensions related to nature and size of effects is consistent with our findings on risk concepts.

- Weakly addressed dimensions in the group related to nature and size of undesired effects are *reversibility of consequences* and *social extent of damage*. Weakly addressed dimensions related to probability and plausibility are *experience with, familiarity with consequences; directness of effects* and *attributability of consequences.* We regard to attributability, we also note that the few assessment studies that did address this dimension only addressed it for changes in *valued environmental properties* (namely: observed temperature change in the IPCC study and observed sea level rise in the Delphic Monte Carlo study). None of the studies has assessed the attributability of *consequences* of climate change.

- Poorly known probabilities - high impact risks of climate change, such as the possible regime shift in the Thermo Haline circulation in the oceans, the possible collapse of the West Antarctic Ice Sheet and the permafrost-thawing-methane release positive feedback, are under-addressed in current climate risk assessment practice. This makes the assessments biased towards moderate climate projections.

4. MATCHING SUPPLY AND DEMAND

On April 24 2001 a workshop was held in which scientists and stakeholders were brought together in a dialogue to elicit the criteria that stakeholders apply to judge (policy) relevance of climate risk information. The aim of the workshop was to confront supply and demand in a open dialogue and to validate the findings of the project. The workshop immediately followed an NRP meeting in which the new findings of the IPCC Third Assessment Report were presented to the stakeholder community. The workshop was set up as a group elicitation process using a heterogeneous group consisting of 18 scientists and stakeholders. Participants were selected in such a way that they covered a broad spectrum of societal groups and institutions with an interest in the climate issue. As preparation to the group elicitation process the participants received the individual task to write down the two most salient or striking observations they had made in terms of (policy) relevance of the information presented during the presentations of the IPCC-SAR or in the policymakers summaries. The elicitation was facilitated by a group moderator who had the task to structure the debate by classifying each observation on (policy) relevance put forward by the participants, as relating to either substance or to process of the assessment. The moderator also asked specific follow up questions to elicit further implications for science and for policy of each observation.

The first round of the elicitation session yielded a list of 34 salient individual observations on policy relevance of climate risk information, using the IPCC-TAR as a key example of present day climate risk assessment practice. After grouping these, the major observations that were elicited are the following:

- Climate risk assessment is perceived by stakeholders to be biased in the following ways:
    - non-linearity and surprise are under-addressed
    - worst case scenarios are not included
    - possible impacts of climate change beyond 4°C or below 0°C are not addressed;
    - the assessment does not look beyond 2100;
    - the focus is on what the *state* of the climate in 2100 may be whereas the *trajectory of accelerated climate change* by 2100 is more relevant than the actual state by that year

- normative, ethical and emotional dimensions of climate risks are not addressed whereas stakeholders perceive the policy relevance of these dimensions to be high

- The assessment fails to clearly address the causal links by which extreme weather events (for which stakeholders think that for communicative transparency the definition should be extended to include intensive precipitation and droughts) are linked to increasing greenhouse gas concentrations
- There is a problem in communicating the *sense of urgency* of the climate problem amongst scientists (high) to society at large (low)
- Criticism on scientific substance of the IPCC assessments as presented by "opponents" in non scientific fora is not adequately dealt with
- The communication by scientists and their institutions of the scientific findings and its uncertainties towards stakeholders and the larger public is perceived to be poor.
- Stakeholders perceive a huge gap between on the one hand the findings that measures and technologies to mitigate climate risks are technically and economically feasible and on the other hand the absence of large scale implementation of these measures and technologies.

In the second round a moderated dialogue was held in two heterogeneous (that is: scientists and stakeholders were not separated) subgroups of nine person each. It was striking that both subgroups independently from each other focussed on risk communication as the major area of improvement in climate risk assessment. Stakeholders had the following observations and suggestions with regard to risk communication and other aspects of the assessment process:

- Scientists fail to communicate the sense of urgency they feel, leading to a problematic mismatch between the low sense of urgency amongst the larger public and the alarming nature of the findings of the TAR. On the other hand, stakeholders don't put much effort in informing themselves. The fact that most of the climate risk assessment studies are published in English also hampers the dissemination of the knowledge amongst the Dutch stakeholder communities.
- Risk communication is hampered by the fact that science and the public speak different languages. This was typically illustrated by the presentation by Van Ulden at the NRP workshop presenting the findings of the TAR where he said that scientifically spoken many uncertainties remained but in ordinary language it was practically certain that man made greenhouse gas emissions are the major cause of observed climate warming.

Another example of a language difference is that science does not include droughts and floods in its definition of extreme events whereas the public considers these extreme events.

- Communicative skills of scientists and their institutions are perceived to be poor and need improvement. Suggestions for improvement include:
  - Train scientists in communication and empathy
  - Scientists should not communicate what they think policy makers should know to scientifically understand the issue, but rather communicate policy meaning of the knowledge
  - Extreme events (with a definition widened to include heavy precipitation and droughts) and worst case scenarios should get a more prominent role in risk communication
  - We may need intermediaries specialised in risk communication to communicate scientific findings and their policy meaning to policy makers and the larger public
- Scientists should take their responsibility and actively engage in the societal debate and contribute to the process of attributing policy meaning to the scientific findings. Scientists have generally refrained from making normative statements. Participants believed that scientists should be more active in communicating to the larger public not only what they *know* but also what they *think and feel* about the risks of climate change.
- Scientists should take their responsibility in contributing to a balanced public understanding of the nature and seriousness of the climate problem that is compatible with current scientific understanding, including the scientific uncertainties. A key task for scientists in this regard is to publicly refute scientifically untenable arguments and to balance biased views on climate change as they are put forward by a few greenhouse sceptics, whose stories currently dominate in the media and who seem to have a mission of deliberately creating public misunderstanding of climate risks. At the same time scientists need be more open in the communication of uncertainties.
- The climate problem is insufficiently imaginable for the larger public. Strong convincing images that frame the thinking about the problem (such as a picture of the hole in the ozone layer in the ozone case) are lacking in the climate case. Extreme weather events may be a good candidate to serve as such an image. This requires a clear, unambiguous, and plausible consistently communicated message addressing the causal linkages between human choice and extreme events.

- The normative, ethical and emotional dimensions require special attention and sophisticated treatment in risk communication on climate change and should be addressed more extensively in future risk assessment studies
- The issue of effectiveness of measures should get better addressed in future assessments

5. CONCLUSIONS AND RECOMMENDATIONS

The design of this project distinguishes between two layers of thought on climate risks, that are labelled as a conceptual layer, taking into account scientific concepts of risk, causality and probability, and an operational layer, linking scientific information to opportunities for policy. It has been assumed that both layers of thought maybe closely linked. However, the conceptual layer of thought maybe found to be dominant among members of the science community and the operational layer of thought mainly among members of the policy community (including representatives of NGOs, business and the like). The findings of the project suggest that this is indeed the case. Moreover, there appears to be a tension between the way of thinking and reasoning among scientists and practitioners at the policy level. The first question to address in this chapter is, to what extent can this tension be explained by a different focus at the conceptual and operational layer of thought? Then, the final and most important question to be addressed is: What ways are open to bridge the gap between approaches to climate risk in the science and policy communities?

In Sub project 1 we found that with regard to impact related constructs, the dimensions that turned out to dominate stakeholders' discourse were:

1) Controllability

    Controllability relates to opportunities to reduce risks by human intervention

2) Seriousness of risk

    This dimension is found to relate to the irreversibility of consequences.

3) Plausibility

    Plausibility refers to a combination of causality, especially reducibility or attributebility of certain phenomena (either physical or human actions) to anthropogenic climate change and imagineability. Plausibility may, in a sense, imply a way of dealing with uncertainty. Instead of 'hard evidence', plausibility requires that scientific reasoning in order to explain certain observations or hypotheses makes sense to the non-expert audience and appeals to their imagination.

Further, our findings imply that stakeholder support for climate policy does not require a full elimination of scientific uncertainty, since uncertainty does not a priori imply relevance. What does make risk information relevant to stakeholders relates to controllability on the one hand and seriousness of impacts on the other. Potential users of climate risk assessments seem to be interested in information on developments of the climate system and climate change impacts that are at the same time destructive and controllable. Plausibility is related to controllability in two ways: First, impacts or events can be causally related to human activities. Secondly, specific human action is likely to reduce or mitigate the specific events or impacts. In summary, stakeholders appear to ask for information on risk seriousness, on controllability of risk (either in The Netherlands or abroad) and on plausibility in a dual respect, i.e. related to anthropogenic causes and to the effectiveness of human action. In fact these findings, although largely based on our interpretation of qualitative data, confirm the findings of earlier projects carried out in the context of the National Research Programme NOP, especially findings from the Policy Options projects (Hisschemöller and others, 1995; also Bernabo and others, 1995). The pivotal outcomes of these projects were that stakeholders want information that (1) help them to overcome the remoteness of the climate issue (in time and space) and (2) helps them to identify interventions that are feasible and yield visible results (in terms of mitigating climate change as well as related issues).

From the results of subproject 2 it can be deduced that scientific risk approaches however underestimate the importance of seriousness of risk and plausibility. The controllability dimension is left aside here, since sub-project 2 did not explicitly address studies focussed on policy options.

Seriousness of risk: The global character of many studies do not allow for exploring specific regional impacts at certain points in time. Yet, this may decrease the perception of distance with the public at large vis-à-vis global climate changes. This is a barrier for communicating the potential seriousness of risk. Another barrier in this respect is provided by the fact that some key-dimensions are weakly addressed, such as reversibility of consequences.

Plausibility: There is a focus on the quest for hard evidence rather than on the relative likelihood and plausibility of climate changes and climate change impacts following from human action. This search for 'scientific proof' seems somewhat odd, given the fact that scientists by the art of their profession operate in a state of uncertainty, where hypotheses and theories are researched until they are replaced by better ones. Therefore, scientists are not bound to take away uncertainty –at least this may not be their primary task- but they may inform society about the possible risks (including likelihood and consequences), i.e. to discuss the plausibility of things that may happen in the context of what may be relevant for their audiences

Interestingly, the tension between what characterises scientific risk approaches and the dimensions that shape the usefulness for scientific risk studies is confirmed at the workshop reported in section 4. In summary, the policymakers would like to see more research effort into extreme cases, regional and local impacts, extreme weather events, and the like. They would like scientists to more openly enter into judgements related to the seriousness of risks, also in the mass media which sometimes appear the grounds for dissenters of the mainstream views within IPCC. In fact, they would like scientists to help bringing the issue closer to the public at large in order to enlarge public support for climate policies. Scientists, on the other hand, stress the authentic responsibility of science and scientists, whose credibility is highly dependent on their ability to maintain some distance from the policy process.

So far, the workshop nicely confirmed the results of subproject 1 and 2. Asked to identify the main area of improvement for matching demand and supply in climate risk research, the workshop addressed the issue of risk communication. (It should be noted here that the independent choice of two subgroups to point to communication as the major issue, may have been influenced by the composition of the group; a stronger representation from the business community would probably have led to identify other problems as well). Without labelling the issue of communication as irrelevant (see the recommendations below), we would still like to take argument with those policy-makers who seem to share too high expectations in this respect. According to our observations, the main bottleneck may be found elsewhere, in the complex relationship between climate science and climate policy-making, which has been institutionally shaped by the IPCC process. We would like to first address the question why the scientific community is reluctant to more specifically address the dimensions seriousness of risk and plausibility? It seems to us that a satisfactory explanation for this cannot be found at the mere conceptual layer of risk, since there are, from an epistemological point of view, no compelling reasons for this reluctance. For a more satisfactory explanation it is necessary to reflect upon two other findings from subproject 2: First, scientific risk studies do not use participatory approaches in order to identify and address conflicting hypotheses or views. Secondly, they show a bias toward moderate projections (i.e. avoid to research extreme events, worst cases and surprise). These characteristics of the prevailing scientific approach to climate risk may cause additional barriers for addressing the dimensions seriousness of risk and plausibility, two of the dimensions that are crucial for policy relevance. But it should be noticed that the combined characteristics of the scientific risk approaches as identified in subproject 2, provide a strong mechanism to foster scientific consensus. Obviously, even a minor shift in the focus of climate risk studies into a direction, which might stress seriousness of risk and plausibility rather than causality and proof might imply speculation, become openly normative, and hence raise scientific controversy. Scientific speculation and controversy are both inherent to the scientific profession, but consensus is a quality highly appreciated at the policy level. So it might be concluded that the explanation for reluctance on the side of the scientific community to address the dimensions seriousness of risk and plausibility is to be found there, where the climate policy communities urge science to come up with consensual research findings. Climate science has, silently and probably not without self-interest, accepted an important rule of the game in the policy process to inflict upon scientific practice. Thus, in a way policy gets what it asked for, but not all consequences are that satisfactory, since the risks of climate change remain quite remote for the public at large.

Having said this, it should also be pointed out that there are good reasons for policy and science to strive for a shared understanding rather than controversy. As has been pointed out and repeated by many authors working in the field of international relations studies, so-called 'epistemic communities' are of crucial interest for the effectiveness of international environmental agreements (Haas, 1989; Underdal 1992). However, as recent developments in the climate negotiations show, a shared view on climate risk presented by an epistemic community from scientists world-wide, may generate completely different responses from governments in Europe and the US. This raises the question of a thorough evaluation of policy-dynamics vis-à-vis science in Europe and the US including a critical reflection of this epistemic-communities thesis.

What can be learnt from this analysis for shaping the Dutch policy-research agenda with respect to climate risk?

1) Research on climate risk might give more attention to extreme weather events, worst cases and surprises. From the dimensions that turned to be relevant to stakeholders as elicited in sub-project 1, the following dimensions need more attention:

- reversibility of consequences
- Plausibility
- imaginability of consequences

- attributability of consequences
- directness of effects

The main target of this effort to widen the plurality of risk studies is to better address the dimensions of seriousness of risk and plausibility, which will open windows of opportunity to bring the risks of climate change to the attention of a wider public than is now the case. But the "price to be paid" is that scientific debate and controversy about impacts and probabilities might increase within the Netherlands. This is not a bad thing in itself, because it may benefit the credibility of climate science in the eyes of stakeholders and the public at large. At the same time, however, it should be prevented that scientific research and debate stand apart from the policy process and the policy discussions. This point is addressed below.

2) The issue of communication should be addressed in several ways, especially

- by further developing existing practices of so-called extended peer review, i.e. procedures which involve non-experts and experts from other disciplines in the various stages of research programmes and projects in order to facilitate the communication and dialogue on underlying values and assumptions as well as to improve the policy relevance of results'
- by initiating comparative assessments on specific topics in order to inform policy-makers and the public at large on convergent and divergent scientific insights. It would be interesting to invite policy scientists, trained in the articulation of argument, to assist natural scientists in presenting and communicating their views. Such an intermediary role is needed, as it should be accepted that good scientists are not always trained communicators.
- by inviting specific target groups in, like business and environmental NGOs, on a semi-regular base, to articulate and interactively discuss their information needs in small settings. Big workshops and conferences are not always the right vehicle to deepen mutual insights in what is and can be expected from climate science.

It might be expected that proceeding along these lines will enhance and stimulate the fruitful utilisation of climate risk research in the societal process of climate risk management.

Summary: Major areas of improvement in scientific work on assessment of climate change risks

Up to now the scientists' work on climate change has suffered from being remote from the concerns of the public. This is not because their problems were more 'scientific', but rather because their choice of problems was conditioned by the culture of research science and the special technical features of climate science.

Scientists must recognise that climate change is not the traditional situation of 'science speaking truth to power'. Rather, they must recognise that uncertainties and value-loadings are integral to the selection and shaping of problems and interpretation of the results.
Scientific integrity is maintained by accommodating uncertainty and engaging with the extended peer community.

Crucial to this new approach is the knowledge that the public now expects disagreement among scientists on complex and contentious issues; the appearance of unanimity only arouses suspicions. The traditional approach, where healthy scientific debate was done in private among consenting scientists and concealed from students and the public, is no longer appropriate.

Research on climate change does not need to be designed around computer models whose outputs are global mean temperatures at some future date. Rather, it can accommodate the public's need for plausibility, focussing on extreme weather events and the regional consequences of the processes of change.

Scientists should recognise that there is no simple solution to the problems of relating research to policy in areas such as this. It is better to be open, with ones public and oneself, about a commitment on the policy side, than to pretend to neutrality. The quality of research, and the integrity of scientists, will be assured by transparency in the debate, which will fully involve the extended peer community.

Scientists could benefit from an improvement of their skills in communication of results and assessments, and from an enhancement of their awareness of the nature of these new problems and of the conflicts in their role.

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7. REFERENCES

Alcamo, J. (ed). (1994a). IMAGE 2.0: Integrated Modeling of Global Climate Change. Water, Air, and Soil Pollution 76, Nos. 1/2.

J. Alcamo, R. Leemans and E. Kreileman, *Global Change Scenarios of the 21st Century, Results from the IMAGE 2.1 model*. Dordrecht: Kluwer, 1998.

Bernabo, C. *et al*., M. Hisschemöller *et al*., J. Klabbers (1996). *Enhancing the effectiveness of research to assist international climate change policy development. Phase I and II final report.* Report No 410 100090 Dutch National Research Programme on Global Air Pollution and Climate Change (NOP), Bilthoven.

J.P. Bruce, H. Lee and E.F. Haites (eds.), *Climate Change 1995: Economic and Social Dimensions of Climate Change*, contribution of Working Group III to the Second Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, 1996, 448 p.

Daamen, C.P.M.; Olsthoorn, A.A. and Feenstra, J.F. *Extreme weather events and climate change – a study of information sources*. Leidschendam: VROM, 1992

De Boer, Joop, Maaike Breukels, William N. Dunn, Matthijs Hisschemoller, Jeroen van der Sluijs (2000). Climate risk assessment: evaluation of approaches WORKING DOCUMENT 1

(Report subproject 1), Institute for Environmental Studies, Free University of Amsterdam and Department of Science Technology and Society, Utrecht University, 28 pp.

Dunn, W.N. (2001, in press). Using the method of context validation to mitigate type III errors in environmental policy analysis. In M. Hisschemoller, R. Hoppe, W.N. Dunn and J. Ravetz (forthcoming). Knowledge, Power and Participation in Environmental Policy. *Policy Studies Review Annual*, Vol 12.

Dunn, W.N. and A. Ginsberg (1986). A sociocognitive approach to organizational analysis. *Human Relations*, Vol 39/11 (955-975).

Dunn, W.N., T.J. Pavlak and G. Roberts (1988). Cognitive Performance Appraisal: Mapping Managers' Category Structures Using the Grid Technique, *Personnel Management*, Vol. 16/3 (16-19).

Fransen, W. and Reuvekamp, A. Eds. (1995) *Probabilities of climatic change*. De Bilt: KNMI.

Haas, Peter M., (1989). *Saving the Mediterranean: The politics of international environmental co-operation*, New York: Columbia University Press.

Van Ham, J.; Van Beers, R.J.; Builtjes, P.J.H.; Können, G.P.; Oerlemans, J. and Roemer, M.G.M. *Risks of non-linear climate change*. Delft: TNO, 1995.

Hisschemöller, M., J. Klabbers, M. Berk, R. Swart, A. van Ulden en P. Vellinga, (1995). *Opties voor klimaatbeleid en hun implicaties voor beleids-gericht wetenschappelijk onderzoek*. Amsterdam, Instituut voor Milieuvraagstukken, R-95/11.

J.T. Houghton, L.G. Meira Filho, B.A. Callander, N. Harris, A. Kattenberg, and K. Maskell (eds.), *Climate Change 1995, The Science of Climate Change*, Contribution of WGI to the Second Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, 1996.

Kates, R.W. and Clark, W.C. Expecting the unexpected. *Environment*, Vol. 38 (2), 6-34, 1996.

J. Klabbers, P. Vellinga, R. Swart, A. van Ulden and R. Janssen, *Policy Options Addressing the Greenhouse Effect*, NRP, 1994.

W.J.M. Martens, *Modeling the Effect of Global Warming on the Prevalence of Schistomomiasis*, Report no. 461502010, RIVM, Bilthoven, 1995.

W.J.M. Martens, J. Rotmans, and L.W. Niessen, *Climate Change and Malaria Risk*, Report no. 461502003, RIVM, Bilthoven, 1994.

Parson, E.A. (1995). Integrated Assessment and Environmental Policy Making, in Pursuit of usefulness. *Energy Policy* Vol. 23 (4-5):463-475.

Patt, Anthony G. 1997. *Assessing Extreme Outcomes: The Strategic Outcome of Low Probability Impacts of Climate Change*". Belfer Center for Science and International Affairs (BCSIA) Discussion Paper E-97-10. Cambridge: Environment and Natural Resources Program, Kennedy (http://environment.harvard.edu/gea/pubs/e-97-10.html); IIASA working paper IR97037, IIASA, Laxenburg.

Rahmstorf, S. (1995), Bifurcations of the Atlantic Thermohaline Circulation in Response to Changes in the Hydrological Cycle, *Nature*, Vol. 378, 1995, p. 145-149.

Rotmans, J. and De Vries, B. (1997). *Perspectives on Global Change, The TARGETS Approach*. Cambridge MA: Cambridge University Press.

Schneider, S.H.; Turner, B.L. II and Garriga, H.M. Imaginable surprise in global change science. *Journal of Risk Research*, Vol. 1 (2), 165-185, 1998.

Titus, J.G. and V. Narayanan (1996), The Risk of Sea Level Rise, A Delphic Monte Carlo Analysis in which Twenty Researchers Specify Subjective Probability Distributions for Model Coefficients within their Respective Areas of Expertise, in: *Climatic Change*, Vol. 33 (2), p.151-212.

Underdal, Arild (1992). The Concept of "Regime Effectiveness", in: *Cooperation and Conflict* Vol. 27, 227-240

Van der Sluijs, J.P. (1997). *Anchoring amid uncertainty; On the management of uncertainties in risk assessment of anthropogenic climate change*, Ph.D. thesis, Utrecht University, 260 pp.

Van der Sluijs, Jeroen P. (2000). Climate risk assessment: evaluation of approaches. Working document 2: Analysis of climate risk assessment studies, Department of Science Technology and Society, Utrecht University. 70 pp.

Van der Sluijs, J.P. (2001) Integrated Assessment Models and the Participatory Challenge The case of Climate Change In M. Hisschemoller, R. Hoppe, W.N. Dunn and J. Ravetz (in press). Knowledge, Power and Participation in Environmental Policy. *Policy Studies Review Annual*, Vol 12.

A.A.J. Vlek (1996), A multi-level, multi-stage and multi-attribute perspective on risk assessment, decision-making and risk control, *Risk Decision and Policy* Vol. 1 (1), 9-31.

R.T. Watson, M.C. Zinyowera, R.H. Moss, *Climate Change 1995: Impacts, Adaptations and Mitigation of Climate Change: Scientific-Technical Analyses*, contribution of Working Group II to the second assessment report of the Intergovernmental Panel on Climate Change, Cambridge University Press, 1996, 878 pp.

APPENDIX 1. LIST OF PARTICIPANTS TO THE WORKSHOP

The following persons have participated in the workshop / diner-pensent "Climate Risk Assessment Evaluation of Approaches", 24 april 2001, Theaterinstituut, Amsterdam:

M. Berk, RIVM

J. De Boer, IVM (moderator subgroup 2)

H. De Boois, NOW-VVA

G. Degens, Nederlandse Aardolie Maatschappij

M. Hisschemöller, IVM (chair / moderator subgroup 1)

M.F. van de Kerkhof, IVM

P. Kloprogge, Universiteit Utrecht (rapporteur plenary and subgroup 1)

M.T.J. Kok, NOP

R. Koopmans, RMNO

T. Kram, ECN Policy Studies

W.J. Lenstra, VROM

B. Metz, RIVM

L.A. Meyer, VROM

D.L. Renkema, OIKOS

S. Schöne, WNF

A. Stevens, Stichting Natuur & Milieu

J.P. van der Sluijs, Universiteit Utrecht (rapporteur subgroup 2)

K. Verbeek, KNMI

A. Verhagen, Plant Research International

APPENDIX 2 PROJECT DESCRIPTION

1. General information

Project title: Climate risk assessment: Evaluation of approaches
(Klimaat Risicoanalyse: evaluatie van benaderingen.)

NRP-theme: IV

Duration: 1 year and 3 months.

2. Contracting organisation:

Department of Science, Technology and Society, Utrecht University
Padualaan 14
NL-3584 CH Utrecht
Tel.: 030-2537600 / Fax: 030-2537601

3. Project leader

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4. Subcontracted institutes:

No	Organisation and address	Responsible Scientist
1	Free University (VU) Institute for Environmental Studies (IVM) De Boelelaan 1115; 1081 HV Amsterdam	Dr. M. Hisschemöller
2	Center for Environmental and Traffic Psychology (COV) University of Groningen Grote Kruisstraat 2 / 1, 9712 TS Groningen	Dr. P.F. Lourens
3	Graduate School of Public and International Affairs University of Pittsburgh, US	Prof. dr. William N. Dunn

5. Abstract of Project and subprojects

With respect to risk approaches in climate risk assessment - scientific results and policy needs may be better tuned. This project aims to identify areas for improvement at the supply-side (science) to better match the demand-side (policy & society). The project seeks to identify the needs and wishes of (potential) users of climate risk assessment. These needs and wishes form the starting point of a demand-driven evaluation of risk approaches in climate risk assessment. The project investigates whether, and if so where and why, there is a mismatch between supply and demand with regard to risk approaches in climate risk assessment. In order to achieve this goal, three sub-projects will be carried out.

1. Identification of needs and wishes of users of climate risk assessment in terms of risk approaches and in terms of subsequent risk information requirements in the context of decision making.
2. Identification and evaluative review of the various conceptual risk approaches that can be distinguished in climate risk assessment studies within and outside the NRP. The project will analyse the possibilities, limitations, strengths and weaknesses of each approach, and will map what kinds of information, insights, answers and perspectives for action, risk mitigation and risk management can be offered by each of the approaches analysed.
3. Confrontation and synthesis of supply and demand, and confrontation and synthesis of the risk approaches identified in this project with the policy approaches that have been formulated in the policy options project (Klabbers et al., 1994).

6. Rationale (Problem analysis; state of the art, relevance)

Within the NRP it has been signalised that, seen form a user-perspective, the expected degree of usefulness of climate risk assessment studies is often not met satisfactory by the actual results from these studies. It has been suggested that the context of decision making has insufficiently been taken into account in climate risk assessment studies. If this hypothesis is right, this omission would limit the usefulness of the results of these studies for actual decision making and therefore would need to be cured. Especially with respect to risk approaches in climate risk assessment - scientific results and policy needs may be better tuned.

The aim of the project is to identify areas for improvement at the supply-side (science) to better match the demand-side (policy and society) with regard to risk approaches in risk assessment of anthropogenic climate change. The project seeks to identify the needs and wishes of (potential) users of climate risk assessment. These needs and wishes form the starting point of a demand-driven evaluation of risk approaches in climate risk assessment. The project investigates whether, and if so where and why, there is a mismatch between supply and demand with regard to risk approaches in climate risk assessment.

Therefore a better understanding is needed of:

- the needs and wishes of (potential) users of climate risk assessment in the context of decision making and the subsequent requirements to risk approaches in climate risk assessment;
- the possibilities and limitations of different risk approaches in risk assessment and subsequent interpretations of the concept 'risk' in the case of climate change.

In the broader field of risk research, a substantial body of work has been carried out on the question how the concept 'risk' should be defined. The term risk denotes the possibility that an undesirable state of reality (adverse effects) may occur as a result of natural events or human activities (Renn, 1992). This notion implies that humans can and will make causal connections between actions (or events) and their effects, and that undesirable effects can be avoided or mitigated if the causal events or actions are avoided or modified. Risk is therefore both a descriptive and a normative concept. It includes the analysis of cause-effect relationships, but it also carries the implicit message to reduce undesirable effects through appropriate modification of causes or, though less desirable, mitigation of the consequences (Renn, 1992).

Within climate risk assessment both within and outside the NRP a multitude of conceptually different risk approaches can be identified. The demand driven-evaluation of these approaches by this project does certainly not strive for the invention of an ultimate risk approach that makes all the others superfluous. Instead the project intends to provide a typology of risk approaches that can accommodate the current diversity of interpretations and connect them in a broader framework in such a way that the merits of each approach become complementary rather than exclusive.

This project distinguishes two layers in risk approaches: an operational layer and a conceptual layer. The operational layer refers to the multidimensional factors that policy actors use to evaluate risks. Following Vlek (1996), we will focus on the following factors (table 1:)

Table 1. Basic dimensions underlying evaluation of risk by policy actors

1. Potential degree of harm or fatality;
2. Physical extent of damage (area affected);
3. Social extent of damage (number of people involved);
4. Time distribution of damage (immediate and/or delayed effects;
5. Probability of undesired consequence;
6. Controllability (by self or trusted expert) of consequences;
7. Experience with, familiarity, imaginability of consequences;
8. Voluntariness of exposure (freedom of choice);
9. Clarity, importance of expected benefits;
10. Social distribution of risks and benefits;
11. Harmful intentionality.

With regard to the conceptual layer of risk approaches we refer to the current practice of climate risk assessment where different approaches can be distinguished. In these approaches, risk is assessed respectively:

- Directly as undesired consequences;
- As possibility of undesired consequences;
- As probability of undesired consequences;
- As seriousness of (maximum) possible undesired consequence;
- As the possibility of catastrophic events and surprise;
- As vulnerability analysis of systems (agricultural systems, ecosystems, water supply systems etc.) with regard to climate change;
- As a multi-attribute weighted sum of components of possible undesired consequences;
- As dystopia's within cultural theory (the possibility that the 'myth of nature' component of your cultural perspective is incompatible with the real response of nature to environmental stress);
- As sensitivity analysis;
- As uncertainty analysis (for instance, as the possibility that unforeseen effects cannot be excluded due to uncertainty in the assessment);
- As ignorance;
- As Type III error (Assessing the wrong risk by incorrectly accepting the false meta-hypothesis that there is no difference between the boundaries of the risk as defined by the assessors and the actual boundaries of that risk.)

Tuning of policy approaches and scientific approaches to climate risks, requires a better understanding of the often diffuse relationship between the operational and the conceptual level in risk assessment and appraisal. Further, in decision making situations, it is important that the actors concerned be informed about those aspects of risk that are important for their particular situation and which links up with their particular responsibility with respect to the risk at hand and with their desired and preferred risk approach. To maximise the scope for action, risk assessment should seek for handles for action in all stages of the causal chain. Key questions in this project are (grouped per sub-project):

Sub-project I Demand-side analysis

1a. How do we identify the variety of risk approaches on the operational level?
1b. What risk approaches can be identified at the demand-side?
1c. What do (potential) users of climate risk assessment perceive to be possibilities, responsibilities and perspectives for human action with regard to climate risk management, including their own?
1d. What conditions need to be met to make climate risk assessment useful for decision making? (evaluation criteria for sub-project III).

Sub-project II Supply side analysis

2a. What approaches to risk on the conceptual level can be identified in climate risk assessment within and outside the NRP?
2b. What are possibilities, limitations, strengths and weaknesses of each of these approaches?
2c. What kinds of insights, answers and perspectives for action, risk mitigation and risk management can be offered by each of the approaches analyzed?

Sub-project III Confrontation and Synthesis

3a What is the match and mismatch between supply and demand regarding risks approaches to climate change?
3b What are the major areas for improvement with regard to risk approaches in climate risk assessment to better match the demand side within the societal process of climate risk management?
3c. (How) can the risk approaches identified in this project be integrated with the policy approaches that have been formulated in the policy options project (Klabbers et al., 1994).

7. Objectives, expected results and deliverables

The overall objective of this project is to identify areas for improvement at the supply-side (science) to better match the demand-side (policy & society) with regard to risk approaches in climate risk assessment.

Subproject 1 seeks to identify risk approaches that underlie the policy questions and preferences as articulated by potential users of scientific risk assessment. It also aims to map the needs and wishes of (potential) users of climate risk assessment and the context of decision making. The results of subproject 1 will be:

- A conceptual framework for the overall project;
- An implementation of grid methodology (Dunn and Ginsberg, 1986; Dunn, 1997, see point 9 of this form) for the identification of risk approaches as desired by (potential) users of risk assessment;
- Measurements (of risk approaches, needs and wishes, context of decision making);
- A working document reporting the results.

Subproject 2 aims to develop a climate-specific typology of conceptual risk approaches in climate risk assessment. It also aims to analyse possibilities and limitations, strengths and weaknesses of each approach. The results of subproject 2 will be:

- A typology of conceptual risk approaches in climate risk assessment;
- A working document providing a state of the art review of risk approaches in climate risk assessment studies within and outside NRP

In subproject 3, the needs and wishes identified in subproject 1 form the starting point of a demand-driven evaluation of risk approaches in climate risk assessment. Subproject 3 aims to identify the major areas for improvement in risk assessment to better match the needs and wishes of (potential) users. The result will be:

- A final evaluation report sketching the major areas for improvement with regard to risk approaches in climate risk assessment.

Subproject 3 will be concluded with a workshop in which the results will be communicated with scientists, policy makers and stakeholders.

7a Description and planning of deliverables

The start-date of the project is 15-12-1999.

Nr	Description (responsible scientist)	Date	Sub-Project
1	Conceptual framework	25-2-1999	I
2	Grid-method	May 1999	I
3	Typology of conceptual risk approaches	Jan. 2000	II
4	Working document "risk approaches demand side"	June 2000	I
5	Working document "risk approaches supply side"	December 2000	II
6	Workshop “Matching supply and demand”	24 April 2001	III
7	Workshop “research agenda for climate risk assessment”	(skipped)	III
8	Final report "Areas for improvement"	June 2001	I,II,III

8. Relevance and potential use of the expected results for science and policy, based on TOR.

The current project is motivated by the observation (see TOR) that - with respect to risk approaches for climate change - scientific results and policy needs may be better tuned. The project aims at identifying and analyzing matches and mismatches between what (NRP-) scientist provide and what policy-makers and other users of climate risk assessment need as far as risk approaches are concerned.

The analysis of the matches and mismatches has relevance for science, for policy and for Programming future NRP projects. Science might profit from the state-of-the-art report describing strengths and weaknesses of the various risk approaches. In addition, scientists will get better insight in the specific needs of policy-makers an other users and these will in turn get a better understanding of what they might and might not expect of the current risk approaches. Evaluation of the discrepancy between what scientists provide and what policy-makers need might guide the further programming of risk projects within the NRP. As a result, policy-makers and other users might get risk approaches at their disposal that are better geared to their specific needs.

In order to increase the relevance and use of the project, the project team suggests to prepare an informal presentation and (in-depth) discussion of the preliminary results with the NRP Program Commission Theme IV and some other experts, in the summer of 1999.

9. Scientific approach and innovative aspects, short description of research plan of projects and sub-projects(s) (activities / planning / methodology).

In summary, the innovative aspects of this project are the following:

- The evaluation of risk approaches will be demand-driven;
- The project implements the grid method of Dunn and Ginsberg (1986) to identify risk approaches;
- The project distinguishes two layers in risk approaches: a conceptual layer and an operational layer;
- The project acknowledges the multi dimensionality and the multi approachability of risks. The project does not strive for the invention of an ultimate risk approach that makes all the others superfluous. Instead the project intends to provide a typology of risk approaches that can accommodate the current diversity of approaches and connect them in a broader framework in such a way that the merits of each approach become complementary rather than exclusive.
- The project seeks for a synthesis of approaches identified in this project with the policy approaches identified in the policy options project (Klabbers et al., 1994).

We will describe the scientific approach per sub-project in more detail.

Sub-project 1: Identification of operational risk approaches, knowledge requirements and needs of (potential) users of climate risk assessment.

This sub-project identifies risk approaches to anthropogenic climate change both conceptual and operational that underlie the policy questions and preferences as articulated by potential users of scientific risk assessment. The project will analyze and map subsequent requirements to risk approaches in climate risk assessment and knowledge needs. Also the (perception of) perspectives and responsibilities with regard to climate risk management of (potential) users of climate risk assessment will be investigated. The project seeks to elaborate the factors that make information generated by climate risk assessments useful or useless for different actors in the context of decision making. Also the project aims to identify criteria that need be met by risk assessment in order to facilitate each actor to make her or his contribution to the societal process of risk management.

The project employs an innovative methodology for identifying concepts, criteria, and approaches governing the demand for scientific information perceived to be appropriate for assessing climatic risks. One of the project scientists, W.N. Dunn, will be principally responsible for developing and applying a "risk assessment grid" which originates in the research procedures originated by the constructivist psychological theorist George Kelly and carried forward by colleagues, mainly in the United Kingdom, over the past 30 and more years. Whereas personal construct psychologists have conducted a great deal of research on clinical decision making, social and policy scientists such as Dunn have further developed and applied Kelly's original "role repertory grid" (see Fransella and Bannister 1977) to problems of public policy decision making (Dunn, Cahill, Dukes, and Ginsberg 1986), technology assessment (Dunn and Ginsberg 1986) and risk assessment (NIOSH 1998).

One of the major instruments of this project is the "risk assessment grid," which is formally defined as a set of cognitive coordinates formed by the intersection of elements of risk (columns) and constructs or criteria (rows) in terms of which these elements of risk are approached by scientists, policy makers, and citizens. The "risk assessment grid" is the product of investigating the multiple constructs, criteria, and frames of reference of different stakeholders. In turn, the process of constructing a risk assessment grid is based on semi-structured interview and/or questionnaire procedures in which the main question is: "How are any two of these three elements of risk alike and different from the third?" Approximately 12-15 elements of climate risk will be randomly grouped in sets of three (triads) as the "stimulus" for the above question. Usually, between 6 and 20 constructs or criteria will be generated from each respondent and plotted on a cumulative frequency graph. It is expected that, within 15 to 35 interviews, a "saturation" point will be reached. In this project, the saturation point is likely to be at or about 100 risk-related constructs or criteria. It is at this point that no new (non-duplicate) constructs or criteria can be offered by succeeding respondents. This "pool" of candidate criteria is an ideal basis for constructing the risk approach grid, which has elements associated with the risk as columns and constructs or criteria as rows.

The grid procedure has three highly desirable properties not shared by the semantic differential, Q-methodology, and similar methods: (1) risk-related constructs or criteria are generated by respondents themselves, rather than imposed by researchers; (2) the approximate limit or range of constructs actually used by a sample of stakeholders (respondents) is reached within a small number of interviews; and (3) this approximate limit of risk-related constructs forms a highly suitable basis for developing self-anchoring rating scales. The cells of the risk assessment matrix, because they contain ratings of all sources of risk according to all criteria, may be analyzed with a wide array of statistical methods—for example, distance-cluster analysis, principal components analysis, regression analysis--appropriate for this and any other matrix of its kind.

This method will thus permit the investigators to reduce the risk assessment grid data to a smaller number of classes or approaches to climate risk assessment.

Because of the nature of the climate problem, every conceivable actor has a potential to contribute to the process of risk management. However the project will be restricted to a limited number of representative key-actors, including government actors (national and local), policy makers, NGOs, industry, insurance sector and consumers. For the selection of actors we will also apply the grid method to minimize the probability that we exclude salient risk approaches or views. The project will attune the selection of actors to the actors that will be covered by the COOL project of NRP theme IV. With regard to the North-South aspects of the climate problem will harmonise our efforts and selection of actors with the NRP project "An Asian Dilemma: Modernising the Electricity Sector in China and India in the context of Rapid Growth and the Concern for Climate Change" (Gupta et al., 1997).

By means of an inquiry with a questionnaire amongst the selected users, combined with grid-method based interviews with a smaller group of selected of key-actors the project seeks answers to the following questions:

a. What is for the user the desired or preferred risk approach to climate change?

b. What is for each risk approach the purpose of climate risk assessment according to the user?

c. What dimensions of risk are deemed salient by that user and why? (the project uses the dimensions distinguished by Vlek (1996) (table 1 of section 6) as starting point).

d. What stages of the causal chain does that user consider to belong to the domain where he is able to act in order to contribute to the management of the risk? (The project uses the causal taxonomy by Norberg-Bohm (1990) as modified by Van der Sluijs (1997) for this purpose).

e. What sources of (climate) risk information does the user use?

f. What do the users deem to be their responsibility with respect to anthropogenic climate change?

g. What do the users see as their (potential) role in the process of risk management?

h. What is their policy-view and what instruments do they consider to belong to their repertoire?

i. What perspectives for action do they see?

j. What specific risk information requirements does the user have / to what extent is that requirement met?

The tasks to be carried out within this sub-project are the following:

- Conceptual framework for entire project (MH, PL, JS, CV, JL, JE, MB);
- Implementation of grid methodology to identify risk approaches, needs and wishes (WD,MH,JS,CV);
- Selection of stakeholder interviewees (MH);
- Drafting of a questionnaire for the inquiry (MH, JS, WD, MB);
- Drafting of an interview protocol (MH, JS, WD, MB);
- Doing the interviews (MB);
- Processing the results of questionnaire and interviews and analyzing the results (MB, MH);
- Drafting of evaluation criteria for sub-project 3 (MH, PL, JS, WD, CV);
- Finalization of the working document “risk approaches demand side” (MH, JS).

Sub-project 2. Identification, classification and evaluation of conceptual risk approaches in climate risk assessment.

At this moment we plan to include the following studies in our analysis.

- IPCC SAR WG-I rapport, WG-II rapport en WG-III rapport;
- Safe Landing Analysis (RIVM);
- Policy options project (NOP)
- Multi criteria decision analysis (IVEM, Van Lenthe);
- Probabilities of Climatic Change (KNMI: Fransen en Reuvekamp);
- Integrated Assessment Models (IMAGE, TARGETS (RIVM), Dialogue (KEMA), FUND (VU, Tol));
- Utopia's/dystopias (Van Asselt en Rotmans);
- Extreme Events (VU)
- Non-linear feedbacks (NOP/TNO/KNMI, van Ham et al.);
- Qualitative uncertainty analysis (Van der Sluijs);
- Risk perception (TUE);

- Surprise scenario's (Kates and Clark);
- Hedging (Ybema, ECN);
- Social Learning in the Management of Global Environmental Risks (The Social Learning Group);
- Delphic Monte-Carlo analysis of sea level rise (Titus and Narayanan, 1996);
- Possible future distributions of tropical diseases (Martens et al., RIVM).

On the basis of published material of these studies the project will identify conceptual risk approaches underlying these studies We will produce an evaluation record of each study of about 4 pages addressing the following questions:

a. What risk approach(es) can be identified in that study?
b. What is the purpose of each risk approach in the context of each study?
b. What dimensions are addressed by that approach(es)?
c. What stages of the causal chain of climate change are covered by that approaches?
d. What are possibilities, limitations, strengths and weaknesses of each approach?
e. How does each study fit in a typology of risk approaches?

For question (e) the project will use Ortwin Renn's (1992) general classification of risks as a starting point, together with the climate specific categories of risk approaches of which a preliminary list has been given in section 6 of this proposal.

The tasks to be carried out within this sub-project are the following:

- Collecting and selecting the published material of each study to be analyzed (JS, PL);
- Analyzing the material (JS, PL);
- Designing a typology of risk approaches in climate risk assessment (PL, CV, JL, JS);
- Processing the results (PL, JS);
- Finalization of the ‘risk approaches supply side’ working document (PL, JS).

Sub-project 3. Confrontation and synthesis: analysis of the mismatch between supply and demand of knowledge regarding the risks of climate change.

On the basis of the results of sub-projects 1 and 2, the project will analyze the match and mismatch between supply and demand of knowledge regarding the risks of climate change. The project seeks to identify areas for improvement of the scientific sub-process of climate risk assessment to better match the demand side within the societal process of climate risk management

When the needs and wishes at the demand-side have been identified from the users (sub-project 1), and the conceptual approaches have been identified from the studies (sub project 2), the conceptual approaches will be evaluated using the following questions and additional evaluation criteria that might follow from sub-project 1:

a. What perspectives for risk mitigation and risk management are provided by each risk approach?
b. To what actors do these perspectives apply?
c. To what phases of the causal chain do these perspectives apply?
d. What progressive problem shifts have been generated by each risk approach?
- does it promote deeper consideration of the risk?
- does it promote consideration of the risk across additional actors?
- does it promote improvements in other risk management functions ? (the project will use the risk management functions formulated by The Social Learning Group (1998), based on the work of Kates et al., 1985)
- does it promote a shift from distributional conflicts to collective problem solving?

e. To what extent does each approach help actors to recognize their specific responsibility with respect to the climate problem?

Within sub-project 3 two workshops will be organized. One workshop with scientists and stakeholders focussing on match and mismatch between supply and demand and how the match can be improved. An other workshop with scientists and NRP focussing on the setting of a research agenda for climate risk assessment.

The tasks to be carried out in this sub-project are the following:
- Evaluate the conceptual risk approaches from a user-perspective (JS, MH, PL);
- Analyzing matches and mismatches by:
- Confrontation and synthesis of supply and demand (JS);
- Confrontation and synthesis of conceptual layer and operational layer of the risk approaches (JS);

- Confrontation and synthesis of the risk approaches identified in this project with the policy approaches that have been formulated in the policy options project (Klabbers et al., 1994) (MH).
- Identification of areas for improvement (JS, PL, MH, CV, JE);
- Organization of 'matching demand and supply' workshop (JS);
- Formulating research challenges and priorities (all);
- Evaluation of methodology (WD);
- Organization of research agenda workshop (JS);
- Finalization of the "areas for improvement" report (JS);
- Finalization of the project (JS).

10. Description of how the project fits in the long-term strategy of the institute(s)

The project will be full-fledged embedded within the research programme of the SENSE research school. SENSE has defined four core-programmes for 1996-2002. The present proposal is embedded in the core programme "Climate Change, Land Use, Biogeochemical Cycles, and Analysis of Policy Options".

The project will form part of the research program Risk Management and Standard Setting of the Department of Science Technology and Society. The research carried out within the Department of Science, Technology and Society is focused on the (potential) contribution of Science and Technology to the realization of a sustainable development of society. In this context two research programmes have been set up, one on 'Energy and Environment' and one on 'Risk Management and Standard Setting. The latter concentrates on the development of appropriate tools for analysis and assessment of environmental risks. The present proposal contributes to this programme by developing new tools for the management of uncertainties in the assessment of global environmental risks.

The project fits in very nicely with IVM reserach priorities, which include the interdisciplinary study of response options to climate change and opportunities for increasing the utilization and usability of scientific knowledge in environmental policy. The project Demand driven evaluation etc. especially relates to the COOL project, the Asian dilemma project in so far as it concerns North-South aspects and the project Knowledge Use and Political Choice, carried out for the Rathenau Institute.

The research program of the Center for Environmental and Traffic Psychology (COV) focuses on the behavioural and social aspects of traffic, transport, mobility and environment. Projects are carried out in the fields of (a) mobility, (b)

11. Description of how the project fits in and contributes to ongoing projects from NRP and other Dutch and International research programmes.

The project fits well in the policy of the NRP theme IV to intensify dialogue activities between science, policy and society regarding the climate problem. The results of the current project can be used in the COOL project (Swart and Hordijk), and results from the COOL project can be valuable for the current proposal. The earlier the COOL project would start, the more profit of cross-fertilization can be expected, which could enhance the usefulness of both projects.

With regard to the North-South dimension in climate risk approaches, the project efforts will also be harmonized with the Asian Dilemma project of the NRP (Gupta et al., 1997). Here, cross-fertilization is also likely because of the overlap in involved researchers (i.c. M. Hisschemöller).

The project is also very relevant in the context of the ULYSSES project (Urban LifestYles, SuStainability and Environmental Assessment), commissioned by EC-DG-XII, part of the fourth framework program. ULYSSES aims at participatory Integrated Assessment by fostering a pluralistic dialogue with citizens, using integrated assessment models of climate change. Models used in ULYSSES are IMAGE, TARGETS an PoleStar. One of the objectives of ULYSSES is to contribute to a discussion about what kind of computer tools for participatory Integrated Assessment (IA) processes could be developed in the future. The results and experiences of ULYSSES with regard to this question (Van der Sluijs and Jäger, 1998) are highly relevant to the current proposal, even while these results are limited to approaches implemented in computer-tools (models).

Other related programs are the GEA project (Global Environmental Assessment, a fellowship program of Harvard University and IIASA, funded by the National Science Foundation (NSF)), led by prof. William C. Clark, (Harvard University). The goal of the GEA-project is to advance understanding of the role of formal assessment activities in societies' efforts to understand global environmental change.

The project "Public Participation in Complex Policy: Democratization of Science in Europe and North America" at the "Center for the Integrated Study of the Human Dimensions of Global Change", led by Janet Stocks, Carnegie Mellon University, aims to develop scientifically sound methods of public participation in complex policy issues. It further addresses two broad questions. The first has to do with how to structure information about climate change so that it is useful to groups of citizens in discussing policy options. Our second question in phase two concerns how policy options devised by non-experts compare with those devised by experts.

The research team of the current proposal has close connections with, and participates in the E-mail discussion groups of each of each of these programs.

References

J.P. Bruce, H. Lee and E.F. Haites (eds.), *Climate Change 1995: Economic and Social Dimensions of Climate Change*, contribution of Working Group III to the Second Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, 1996, 448 p.

W.N. Dunn, *Cognitive Impairment and Social Problem Solving: Some Tests for Type III Errors in Policy Analysis*, Graduate School of Public and International Affairs, University of Pittsburgh, 1997

Dunn, W.N., Cahill, A.G., and Kearns, K.P. (1985). Assessment of Occupational Frames of Reference. Final Report, Department of Personnel, Comprehensive Employment and Training Act Division, City of Pittsburgh, January, 1985.

Dunn, W.N., Pavlak, T.J., and Roberts, G. (1988). "Cognitive Performance Appraisal: Mapping Managers' Category Structures Using the Grid Technique." Personnel Management 16,3 (January, 1987): 16-19.

Dunn, W.N. and A. Ginsberg (1986). "A Sociocognitive Approach to Organizational Analysis." Human Relations 39,1: 955-975.

Fransella, F. and D. Bannister (1977). A Manual for Repertory Grid Technique. London: Academic Press.

J.Gupta, E. Worrell and C. Kroeze, *An Asian Dilemma: Modernising the electricity sector in China and India in the context of rapid economic growth and the concern for climate change*, NRP Project proposal, Amsterdam, April 1997.

J.T. Houghton, L.G. Meira Filho, B.A. Callander, N. Harris, A. Kattenberg, and K. Maskell (eds.), *Climate Change 1995, The Science of Climate Change*, Contribution of WGI to the Second Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, 1996.

R.W. Kates, C. Hohenemser en J.X Kasperson, Perilous progress: managing the hazards of technology, Boulder, Westview, 1985.

J. Klabbers, P. Vellinga, R. Swart, A. van Ulden and R. Janssen, *Policy Options Addressing the Greenhouse Effect*, NRP, 1994.

W.J.M. Martens, *Modeling the Effect of Global Warming on the Prevalence of Schistomomiasis,* Report no. 461502010, RIVM, Bilthoven, 1995.

W.J.M. Martens, J. Rotmans, and L.W. Niessen, *Climate Change and Malaria Risk,* Report no. 461502003, RIVM, Bilthoven, 1994.

National Institute of Occupational Safety and Health (1998). Phase II Strategic Planning Report--Risk Assessment Project Prioritization. Pittsburgh and Spokane: NIOSH Research Laboratories. W.N. Dunn Consultant.

V. Norberg-Bohm, W.C. Clark, M. Koehler, and J. Marrs, Comparing Environmental Hazards: The Development and Evaluation of a Method based on a Causal Taxonomy of Environmental Hazards. In: W.C. Clark (Ed.), *Usable Knowledge for Managing Global Climatic Change*, Stockholm Environmental Institute, 1990.

Renn, O., Concepts of Risk: A Classification, in: Krimsky and D. Golding (eds), *Social Theories of Risk*, Westport CT, Greenwood, 1992, 251-273.

The Social Learning Group, *Learning to Manage Global Environmental Risks: A Comparative History of Social Responses to Climate Change, Ozone Depletion and Acid Rain*. MIT Press, forthcoming.

J.G. Titus and V. Narayanan, The Risk of Sea Level Rise, A Delphic Monte Carlo Analysis in which Twenty Researchers Specify Subjective Probability Distributions for Model Coefficients within their Respective Areas of Expertise, in: *Climatic Change*, **33** (2), 1996, p.151-212.

J.P. van der Sluijs, *Anchoring amid uncertainty; On the management of uncertainties in risk assessment of anthropogenic climate change*, Academisch proefschrift, Universiteit Utrecht, 1997, 260 pp.

M.B.A. van Asselt and J. Rotmans, Uncertainty in Perspective, in: *Global Environmental Change, Human and Policy Dimensions*, **6** (2), 1996, p. 121-157.

A.A.J. Vlek, A multi-level, multi-stage and multi-attribute perspective on risk assessment, decision-making and risk control, *Risk Decision and Policy* **1** (1), 9-31, 1996.

R.T. Watson, M.C. Zinyowera, R.H. Moss, *Climate Change 1995: Impacts, Adaptations and Mitigation of Climate Change: Scientific-Technical Analyses*, contribution of Working Group II to the second assessment report of the Intergovernmental Panel on Climate Change, Cambridge University Press, 1996, 878 pp.

APPENDIX 3 LIST OF PROJECT PUBLICATIONS

De Boer, Joop, Maaike Breukels, William N. Dunn, Matthijs Hisschemoller, Jeroen van der Sluijs (2000). *Climate risk assessment: evaluation of approaches WORKING DOCUMENT 1* (Report subproject 1), Institute for Environmental Studies, Free University of Amsterdam and Department of Science Technology and Society, Utrecht University, 28 pp.

Van der Sluijs, Jeroen P. (2000). *Climate risk assessment: evaluation of approaches. Working document 2: Analysis of climate risk assessment studies*, Department of Science Technology and Society, Utrecht University. 70 pp.

J. van der Sluijs and P. Kloprogge, The inclusion of stakeholder perspectives in Integrated Assessment of Climate Change, in Michael Decker (Ed): *Interdisciplinarity in Technology Assessment. Implementations and their Chances and Limits.* Series: "Wissenschaftsethik und Technikfolgenbeurteilung", Volume 11, Berlin Heidelberg New York 2001.

APPENDIX 4 COORDINATION WITH OTHER PROJECTS AND PROGRAMMES

There have been synergies between this project and *inter alia* the following programmes:

EU-ULYSSES project (Urban Lifestyles, Sustainability and Integrated Environmental Assessment) supported by the European Commission, DG XII , RTD Programme Environment and Climate, area "Human Dimensions of Environmental Change"), which has been coordinated by Carlo Jaeger at Darmstadt University of Technology, Germany.

"Coping with Value Diversity in Integrated Assessment Models of Climate Change", Ph.D. project of Penny Kloprogge, 1999-2003, Department of Science Technology and Society, Utrecht University (Promotor: Prof. Dr. Wim Turkenburg, co promotors: Dr. Jeroen van der Sluijs, Dr. Jerry Ravetz).

European Forum on Integrated Environmental Assessment (EFIEA). EC DG XII Concerted Action program, coordinated by prof Pier Vellinga, IVM, Free University of Amsterdam.

APPENDIX 5 ATTENDANCE AT NATIONAL AND INTERNATIONAL MEETINGS

(This list is limited to meetings attended by the project leader and related to this project)

10-03-99 tm 12-03-99 project meeting of European ULYSSES project (Urban Lifestyles, Sustainability and Integrated Environmental Assessment, supported by the European Commission, DG XII , RTD Programme Environment and Climate, area "Human Dimensions of Environmental Change"), Brussel.

29-03-99 Study day "geintegreerde Modellen" organized by RMNO, Oegstgeest.

10-18 July 1999 European Forum on Integrated Environmental Assessment - Uncertainty workshop, Baden.

20 Sept- 1 October 1999 EU-Advanced Course in Decision Tools and Processes for Integrated Environmental Assessment, Barcelona (Autonomous University of Barcelona) Jeroen van der Sluijs presented a lecture "Uncertainty and Quality in Integrated Environmental Assessment" in which materials from this project were used.

13-15 September 2000 Euro Conference Implementation and Limits of Interdisciplinarity in European Technology Assessment", Bad Neuenahr, Germany. At this conference Jeroen van der Sluijs gave a presentation 'The inclusion of stakeholder perspectives in Integrated Assessment of Climate Change' (see also Appendix 3).

6 April 2001 Guest lecture 'Post Normal Science, the case of climate change' by Jeroen van der Sluijs at "Centrum voor Bioethiek", Utrecht University,

12-19 July 2000 EFIEA workshop Scaling Issues in Integrated Environmental Assessment, Maastricht.

1-3 November 2000 ICIS-workshop: Dealing with uncertainty in environmental management, Maastricht

15-16 March 2001 EFIEA: European Forum on Integrated Environmental Assessment Concluding Workshop

24 April 2001 Workshop Nieuwe Inzichten in de klimaatproblematiek; de uitkomsten van het Third Assessment Report van het IPCC, Rode Hoed, Amstedam