Decision Support Tools

Midterm review report

Knowledge for Climate Theme 8

Ekko van Ierland Consortium leader

with contributions of work package leaders

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Contents

1. Introduction

The program of Knowledge for Climate (KfC) Theme 8 Decision Support Tools aims at improving tools for design and evaluation of adaptation strategies with a special focus on spatial planning and cross cutting issues. The program focuses on three core elements 1. tools for formulation of the adaptation task, based on climate scenarios and economic development 2. tools for development and visualization of adaptation strategies in general and in particular related to hotspots and case study areas of KfC; and 3. evaluation and monitoring tools for assessing adaptation strategies in terms of various indicators such as costs and benefits; side effects; equity issues; efficiency and temporal and spatial scales. The program elaborates on results of previous research (NOP, BSIK, EU programs) and extends the analysis in order to make further progress in the scientific domain and in order to apply the results in the context of the case studies and hotspots of KfC in close consultation and collaboration with stakeholders.

The program is contributing to the ongoing planning process in the Netherlands at various levels, such as Deltaprogram and current Regional Strategic Visions (Structuurvisies), the National Adaptation Strategy (NAS) and the execution of national policies, for instance in Haaglanden and Rotterdam.

In the past two years the program has been focused on the implementation of the research projects as scheduled in the proposal. All the WPs have started according to schedule with the exception of WP4 and WP7. In WP4 the position of a PhD candidate could not adequately be filled and the work has been taken over by a senior researcher. WP7 started later than scheduled due to the illness of the WP leader, but through a rescheduling of the activities the original targets will be met in both WPs.

In general Theme 8 is well on schedule and most of the PhD candidates, researchers and postdocs are working according to the work plan as indicated in the proposal. However in work package 4 the work of a PhD candidate has taken over by a senior researcher, after two PhD candidates resigned. In WP7 some changes have taken place related to the illness of the project leader. PhD candidates are successful in following the training program of the graduate schools and they are writing the first texts for their manuscripts.

The hotspot Haaglanden (which is in the most densely populated western part of the Netherlands) has been selected as the central hotspot for Theme 8, although some WPs are also making contributions to other hotspots. For Haaglanden the focus sofar has been on the theme of urban heat islands and on water management.

For urban heat islands we developed according to the framework scenarios for economic development and climate change in order to assess the problem of urban heat islands in Haaglanden. Jointly with Haaglanden we have been looking into adaptation options in terms of changes in the urban infrastructure to reduce the heat island effect. For water management we are analyzing the projected climate change impacts and the adaptation options by means of cost benefit analysis and decision making under uncertainty in work package 6. These are 2 examples of how the integration of information from various work packages is taking place in the central case Haaglanden. The collaboration with the Central Hotspot Haaglanden is very productive and in 2011 three workshops were organized to consult with the stakeholders in Haaglanden. The first workshop was scheduled to elaborate on the follow up workshops on “Urban Heat Islands” and “Regional Water Management”.

The details of the progress in the theme are given in section 6 for each WP.

2. The mission of the programme

2a. The mission of the program Decision Support Tools

Although many studies have focused on adaptation options, so far only rather general inventories and results have been obtained. With ongoing climatic change an urgent need exists to develop, to improve and to apply scientific methods and tools that can provide for an optimal temporal and spatial planning of adaptation options for the various sectors and regions in the Netherlands, with a potential to be used in various countries of the world. This means that the most suited scientific methods and the best tools need to be developed to clearly define the adaptation tasks; to identify alternative options; to assess these options and to select the best options for a systematic implementation by the various relevant stakeholders. The program contributes to research at the front of the disciplines involved in adaptation research by contributing to defining the adaptation challenges, based on a combination of socioeconomic and climate scenarios; given the uncertainties in both the climate scenarios and the economic development at the regional level this poses new questions to spatially explicit modeling of human activities and the impacts of climate change; in this context the Landuse Scanner Model will be improved and extended.

An important scientific issue is how to assess the economic damages of flooding. Although the direct damages can be relatively easily assessed, the secondary impacts are difficult to establish and need more attention. The program makes an innovative contribution by modeling the impacts of flood risks, in particular focusing on assessing secondary damages of flooding (an issue that is not yet satisfactorily dealt with so far).

As adaptation involves almost all sectors and actors in the economy and in all regions, very specific knowledge is required on the impacts of climate changes on these specific sectors and regions. In order to make best use of the local knowledge of stakeholders, new methods for the iterative interaction with stakeholders will be developed to obtain the best information and best perspective on adaptation options.

Visualization is used to inform stakeholders on the risks and opportunities of climate change at the regional level. Particularly innovative is the visualization of the hydrological impacts of heavy rain in polders under various circumstances through hydrological modeling directly linked to precipitation and the visualization of the impacts in a very detailed manner.

The risk of prolonged periods of drought asks for a complete revision of the strategies on fresh water allocation and storage in the Netherlands. This aspect has been stressed by the Delta Committee, which suggested to substantially raise the water level in Lake IJssel. Integrated hydro-economic modeling of fresh water resources demand and supply in the Netherlands, both at the national and regional river basin level is necessary to ensure cost-efficient solutions for future freshwater provision. The program will make innovative contributions in this domain by (i) integrating the hydrological and economic aspects of freshwater resources allocation under climate change in a joint approach, (ii) designing spatial (dis)aggregation procedures to analyze regional and national impacts simultaneously in a consistent and coherent way, and (iii) examining the possibilities of introducing water markets to deal with future freshwater allocation problems.

An important contribution of the program is the study on the optimal timing of adaptation and the issues related to discounting (this topic is still unsolved as stressed by the Stern report and related discussions and by the Deltacie, which did not elaborate on the timing of adaptation measures); The results of an improved understanding on the timing of the measures (related to fixed costs,

irreversibilities, hyperbolic discounting and real option theory), will be made available for stakeholders in hotspots of KfC and for national, regional and local policymakers.
The monitoring of adaptation policies and the indicators to be used are new topics that hardly received scientific attention so far. The program contributes to the definition and selection of appropriate indicators and their use in the implementation phase of adaption measures. This enables effective and efficient monitoring and identification of domains, sectors, categories of stakeholders or regions that will require additional attention in order to adapt to climate change. This issue is closely related to optimal timing of measures.

2b. To what extent have the original targets been changed?

The original objectives and planning have not been changed, but WP 7 has some delay in its implementation due to illness of the WP leader.

3. Approach of the overall program Decision Support Tools

3a. Structure of the program Decision Support Tools

It is an important challenge to define a coherent adaptation strategy and to develop adaptation measures that are well designed and flexible, and that meet various criteria such as efficiency (in spatial and temporal perspective), coherency (e.g. in integrating cross sectoral aspects), innovativeness (in terms of exploiting new technological options and new options provided by climate change) and effectiveness.
The problem definition of the program is to improve the tools for defining the adaptation challenges for the various sectors and areas in the Netherlands and to develop, to improve and apply tools for the development of a coherent *strategy for adaptation and implementation of practical adaptation measures, a*nd to improve the evaluation tools to further optimize the options and to select the best packages of adaptations options.

This results in the following research questions:

1. How can - in a dynamic context and given the uncertainties related to climate change- the targets be identified for adaptation in the various sectors and the various regions of the Netherlands and what will be the desired timing?
2. How can a consistent adaptation strategy and alternative and innovative adaptation options be generated, both in terms of changes in infrastructure and changes in behavior and society, in order to cope with climate change and to make the Netherlands climate proof?
3. How can assessment and evaluation tools be developed and applied for adaptation in the various regions in the Netherlands and for the various sectors and hotspots, including crosscutting issues?

For research question 1 this requires new scientific methods to consider uncertainty issues and climate change impacts and issues like the optimal timing of the various targets for adaptation (How much needs to be done and when?)

For research question 2 we want to identify in close collaboration with the stakeholders in the various hotspots of KfC what alternative options are available, ranging from technical to behavioral and institutional options and what are the most promising ones and how can this be integrated in a consistent adaptation strategy?

Under research question 3 we will focus on the urgent and remaining issues related to the costs and benefits of the options, in particular the optimal timing of the implementation, the cross sectoral issues, discounting and the flexibility in the timing of the various steps in the implementation of the strategy and the relevant adaptation options.

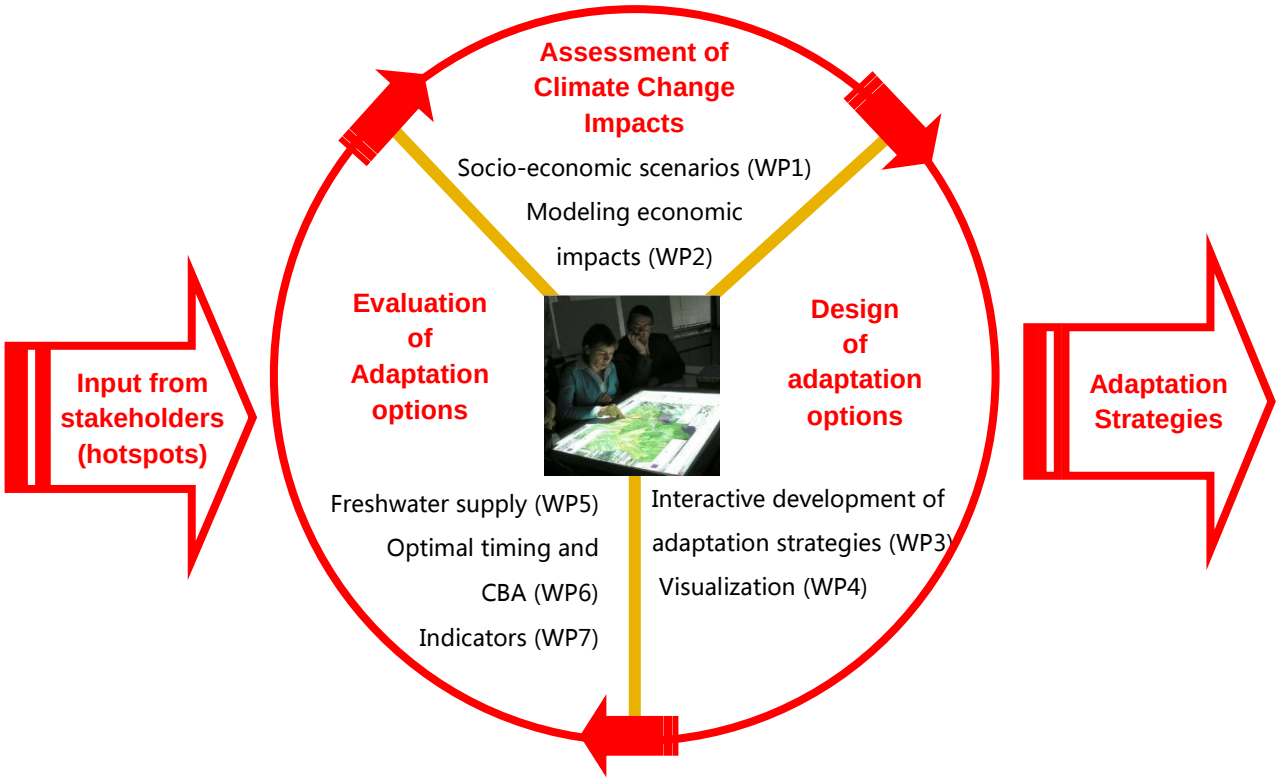

Figure 1. Outline of the program Decision Support Tools and research approach

Figure 1 shows the integrated nature of the program and the interactions between the three core domains and the WPs . In the top segment of *Assessment of climate change impacts* we focus on the assessment of climate change impacts by means of socioeconomic scenarios (**WP1**) and the modeling of flood risks (**WP2**). In the domain of *Design of adaptation options* we focus on interactive development of spatial adaptation strategies (**WP3**) and on visualization and communication of adaptation (**WP4**) in consultation with stakeholders and KfC hotspots, by means of innovative visualization techniques and interactive design interfaces. In the third domain of *Evaluation of adaptation options* we focus on the costs and benefits of the options and the selection of the best options based on the various criteria, such as efficiency, equity, spatial impacts, and timing. This is done by modeling the options for fresh water supply (**WP5**) and by studying assessment methods for developing a strategy and adaptation measures (**WP6)**, particularly focusing on temporal aspects and optimal timing. By developing and selecting indicators the program contributes to efficient and effective monitoring of the implementation of adaptation in the Netherlands at various scale levels (**WP7**). Through regular consultation and exchange of information in the program board and in workshops the WPs will be coordinated and from the start of the program we focus on the integration of the insights obtained in the individual work packages. The topics of research are selected not to give coverage to

all aspects of adaptation, but explicitly to cover a number of topics that urgently need additional attention in the context of KfC in order to serve the needs of the policymakers and the stakeholders. Apart from contributing to WP1 and WP7, the Netherlands Environmental Assessment Agency (PBL) will take an effort in fine-tuning the program, ensuring that questions will be answered that are relevant for the preparation of the adaptation strategies in the Netherlands in the policy context and at the regional and local level. Much of the information for this will be generated in the PBL project "roadmap to a climate proof Netherlands".

3b. Relations with other KfC themes

The work packages are linked as is indicated in Figure 1. The team includes researchers with different disciplinary background including natural scientists focusing on hydrological modeling, spatial economists and landuse modelers and environmental economists. Also through the cooperation with the themes 1-7 of KfC the best disciplinary skills are available to the program. The themes of KfC are:

1. Climate Proof Flood Risk Management
2. Climate Proof Fresh Water Supply
3. Climate Adaptation for Rural Areas
4. Climate Proof Cities
5. Infrastructure and Networks
6. High-quality Climate Projections
7. Governance of Adaptation
8. Decision support tools

The interdisciplinary approach is based on profound knowledge and expertise in the individual disciplines and specific skills on interdisciplinary cooperation of the various leading researchers in the consortium. A detailed elaboration is given in the report per WP in section 6.

3c. Contributions to Deltaprogramme or other national and international (e.g. EU programmes)

Researchers in KfC Theme 8 are contributing to a large number of national and international activities. At the national level researchers are contributing to the deltaprogramme in several settings. Some of the researchers of Deltares directly contribute to the work of the Deltaprogramme and other (e.g. Prof. van Ierland) are involved as advisors to the Deltacommisariaat on economics.

In the international context researchers are contributing to the EU-programme Mediation http://mediation-project.eu/ which is one of the leading programmes on climate adaptation in the EU. The mediation programme is also related to the EU programme Climate costs and to the clearing house programme of the EU.
Researchers also contribute to climate adaptation research in the context of the Delta Alliance, particularly by means of the KfC funded programme on Climate Adaptation in Jakarta (JCAT), led by Dr. Philip Ward of IvM-VU http://www.delta-alliance.nl/projects/jakarta-climate-change-adaptation-tools .

4. Results for the Midterm review for Decision Support Tools (mid 2012): Detailed reports per work package

WP1: Integrating and downscaling national socio-economic scenarios

Prof. dr. Piet Rietveld; dr. ir Eric Komen; dr. Ir. Peter Verburg

A1 Aim and approach of WP1

The development of effective regional climate adaptation perspectives not only requires information on climate change but also calls for the consideration of changing economic and societal conditions. Land-use models are suitable tools to downscale existing national scenarios into changes in local land-use patterns and thus provide the relevant context for the development and evaluation of climate mitigation and adaptation measures. The Land Use Scanner model was successfully applied in this context in the current CcSP and KfC programs. These applications have, however, indicated two important drawbacks: 1) current regionalised sector-specific outlooks on the future based on national scenarios lack a thorough integration; and 2) the translation of sector-specific development (e.g. number of new residences) and spatial measures for climate adaptation into a related demand for space (in hectares) used in the land-use model lacks the accuracy and flexibility needed for climate-related impact assessments and the development of adaptation alternatives. Moreover, multiple functionalities on the same land area are not fully considered. Multifunctionality of land is a high priority in the densely populated regions of the Netherlands and often a means of adapting to climate change conditions.

This work package thus has the following objectives:

1. better align and integrate the sector-specific models for, amongst others, residential, commercial and agriculture development. This integrated approach will ensure a more robust link with the underlying scenario assumptions and allows for the incorporation of feedbacks between climate-induced and other developments in different economic sectors. This work will be performed in cooperation with the Netherlands Environmental Assessment Agency (PBL).

revise the model to allow the incorporation of functional units (e.g. residences, water storage quantity) rather than hectares. This enables a more flexible inclusion of issues such as land-use intensity and multifunctionality, allowing, for example, a more accurate assessment of flood risk and a wider scope of adaptation measures.

B1 Relations with other KfC themes

WP 1 has intensive relations with KfC themes 3 and 6. As part of the service function associated with this project scenario-based projections of land-use change for 2040 have been provided to these projects. These data are also shared through the Climate impact portal managed by the Royal Netherlands Meteorological Institute as part the KfC-Tailoring/KfC-theme 6 project. In addition several meetings have been organized with researchers and stakeholder from KfC Theme 3 to discuss how the land-use maps and socio-economic scenarios can be used in the theme 3 case study areas.

C1 Contributions to Deltaprogramme or other national and international (e.g. EU programmes)

Our research into the improvement of the Land Use Scanner modeling tool and implementation of socio-economic scenarios currently finds its way into the scenario-based simulation of land-use changes in the Delta programme. This is achieved through cooperation with the Dutch Agricultural Economic Institute (LEI) and PBL Netherlands Environmental Assessment Agency.

In addition we cooperated with the Department of Primary Industries, Victoria, Australia in a proposal for a joint-research effort in simulating agricultural land-use changes in relation to climate change. This

proposal successfully passed the first review round, but did not make it through the second round as a result of budget cuts in Australia. New ways of cooperation are currently being discussed.

With our other foreign partner, EC-Joint Research Centre, we discussed the implementation of scenarios and further development of their land-use modeling framework. We further worked on a project proposal through which the relationship with EC-JRC can be strengthened.

D1 Research results for WP1
Fall 2010, we started reviewing various scenario implementations in Land Use Scanner modelling projects during the period 2005-2008. A first result of the research is that a series of necessary model-corrections (bugs) and other improvements have been implemented.

At the end of 2010 the first meeting with PBL took place to synchronize the modelling work and research carried out in this project with the work done by PBL, in order for our project results to be used directly in policy-relevant studies such as the Deltaprogramme. This cooperation resulted in an update of the socio-economic scenarios that have been made available to other KfC-Themes and projects. Building on this modeling work, the relationship with PBL was further intensified. From 1 October 2011 to the end of the year, a PBL researcher was positioned at the VU University Amsterdam to further synchronize the development/update of socio-economic scenarios (project 1) and to jointly work on model improvement (project 2).

The scenarios have further been used during a first workshop for the Haaglanden case in November 2011. This workshop emphasised on the one hand on heat stress and the influence of projected urbanization on changes in the experience of heat and mortality rates, and on the other hand on the simulation of changes in urban density in general.

May 2012, we finish the inclusion of a new base year (2008 instead of 2006) and a detailed report on the current status of the model- and scenario updates and further synchronization with the Deltaprogramme scenarios in which PBL acts as lead partner and in which especially the modeling of the agricultural sector receives ample attention.

Next to this, in project 1 we have depicted a range of options for integrating spatial developments of various sectors within a modeling environment. A joint literature study with PBL on urban land use, the importance of accessibility for spatial developments and how to integrate this knowledge in the Land Use Scanner model was carried out resulting in two reports. Following this study, ample attention has been paid at the functioning of the land market and the conclusions we can draw from that for the understanding of land use change as well as how to operationally describe the suitability for different land use functions. This analysis has been published as a peer-reviewed book chapter. Where relevant, this new knowledge shall be used when revising the socio-economic scenarios, for example in the definition of suitability of land for urban uses.

In order to prepare for the simulation of urban densities (project 2) we sought cooperation with Dr. Moshe Givoni (Senior Researcher, Transport Studies Unit, School of Geography and the Environment, University of Oxford) for an analysis of factors that explain differences in urban densities. During this research we also contributed to a Masterclass ‘Models in Urban Planning’. Another result delivered during this preparatory phase (project 2 – July 2011) is a thesis of a student in the Bachelor Earth and Economics (Walda, 2011) who examined the influence of various spatial driving forces on population shrink in different regions.

Next, research was done to examine the actual inner urban densification during the period 1998-2006 in relation to the policy ambitions that were maintained at the time. Special attention has been paid to

the developments in the joint-case study area Haaglanden. The results of this analysis have been presented at the 'PBL Ruimteconferentie' in Rotterdam and were received with a lot of interest. As a consequence, an article was published in the practice-oriented journal 'Binnenlands Bestuur'. This analysis forms the basis for further model developments and has already played an important role in the scenario results and heat stress calculations presented in November 2011 at the aforementioned first workshop for the Haaglanden case with stakeholders.

In December 2011, the urban density analysis as well as a framework for the modeling of changes in urban densities were presented at the Complex City Workshop at the Tinbergen Institute in Amsterdam. In April 2012, researchers from VU-FEWEB and PBL presented initial simulation results of residential density change at the special workshop on Complexity Modelling for Urban Structure and Dynamics at the AGILE conference in Avignon. An adapted Land Use Scanner configuration was used for this purpose, in which the option to simulate residential land use using variations in densities was made possible. A paper describing the revised modeling framework and initial simulation results is currently being prepared for publication as part of an edited book volume or peer-reviewed journal.

In project 2 research focused on the insertion of multifunctional land use in the modeling approach. The first aim was to attach an economic value to a range of services (recreation, beauty, cultural heritage, inspiration et cetera) that are delivered by agricultural landscapes. This value was determined with a stated preference analysis among tourists in the municipality of Winterswijk. The study also aimed to quantify and map cultural ecosystem services through participant assessment of landscape features and structure. First results have been presented at the Ecosystem Services Partnership (ESP) conference in Wageningen and are accepted for publication in the journal of Ecological Indicators as a peer-reviewed paper .

Further in project 2, tests were carried out to analyse how an integrated method using a combination of an Agent Based model and back-casting techniques could help stakeholder formulate rural policies more effectively. In the related workshop a model was used to simulate the evolution of landscapes based on rural actors' management decisions, environmental conditions and EU policy. Two scenarios have been used: 1) subsidies for landscape management, assumed to result in increased green services; and 2) liberal market with less subsidies for all farmers. The purpose of the simulation was to come up with desired functions for the region and to generate ideas on how these goal can be achieved. A range of stakeholder participated in this workshop including stakeholders from LTO, Plattelandshuis, Water management board Rijn and IJssel, spatial planners and policy makers of municipalities in the region, the province of Gelderland and the Ministry of EL&I. Participants were enthusiastic and interested in the results. Especially the maps of the model simulations were valued since they illustrate how local and exogenous (policy changes, global markets) processes result in specific location changes. The conclusion was that when policies are formulated, the method is suitable to integrate knowledge of stakeholders, scientists and policy makers and discuss the possibilities and whishes with regard to development of a region.

E1 Impact on society

As a social result, we can mention the fact that the updated scenarios have been used during a presentation at the symposium '75 year Vechtplassencommittee', one of the oldest local stakeholder groups in the Netherlands.

Another social impact was our contribution, in co-operation with the 'Fries Dagblad', to a public meeting about new commercial and industrial sites. This was a nice opportunity to bring our knowledge about demand for space for this specific sector to the attention of a broader public and at the same time receive feedback from practice/society on this topic.

Additionally, the knowledge obtained in this project is transferred to future researchers and practitioners through various educational activities. Methods and results developed in this project are being used in the course on land-use change in the BSc programme Earth and Economics, the MSc programme on Geographical Information Science (UNIGIS) and the Urban Environment Lab of the Amsterdam University College. Results have also been used as case study examples in the PhD summer course attached to 4th ESP conference co-organised by VU university and Wageningen.

Project reports have been disseminated to stakeholders in Achterhoek describing the result of model findings. Further work will be conducted in the Achterhoek region and effort has been made in continuing our working relationship with the existing stakeholders. Stakeholders are enthusiastic about future collaboration.

Academic publications have resulted in exposure and impact in the scientific community. Approaches using modelling and backcasting, as well as, the quantification and mapping of cultural service are subject at the forefront of both esosystem service and decision support research.

F1 Conclusions and prospects

- The joint-research effort between VU-FEWEB and PBL is productive. The update of the socio-economic scenarios has taken more time than anticipated, but as a direct consequence the different model configurations used by VU-FEWEB and PBL are synchronized and project results are actively being used in policy-relevant projects such as the Deltaprogramme;
- Model improvements and adaptation to make the modelling framework suitable for the simulation of variations in residential densities are on schedule;
- More insight into the driving factors causing an increase in urban density (e.g., what is the ‘tipping point’ when the decision is taken to start high-rise building) is needed, as well as more knowledge on how to incorporate multi-functional land use modeling in the Land Use Scanner model.
- Studies in the Achterhoek have revealed a number of insights into spatial and temporal determinants of adaptation and multi-functionality in an Agricultural landscape. A close working relationship has ensured high societal relevance
- While major work has been completed in the Achterhoek, the establishment of local understanding and networks of stakeholders will allow for further research which will be conducted in the EU FP7 project CLAIM.

WP2: Assessing the Economic Impacts of Flood Risks

Workpackage leader: Prof.dr. M.W. Hofkes (VU-IVM); in cooperation with Dr. O. Ivanova (TNO) and Dr. N. Pieterse (PBL)

A2 Aim and approach of WP2

What are the indirect and long-term consequences of disastrous flood events? WP2 intends to construct economic models that will be employed to investigate how the effects of a flood ripple through the regional and national economies. Particular attention will be devoted to adaptation by households, dampening such effects over time. The modelling approach will be to combine an existing Computable General Equilibrium (CGE)-model with elements from agent-based modelling. The CGE-model we will use – RAEM - is well suited to study how changes in factor and product prices affect different sectors across regions in the Netherlands. However, this model does not include an adequate level of individual detail to capture the complex mechanisms involved in the adaptation processes. Agent-based models, which focus on heterogeneity of agents and interaction between them, will therefore enhance the existing modelling framework. The project is carried out in co-operation between TNO Delft, and the Institute for Environmental Studies of VU Amsterdam.

B2 Relations with other KfC themes

There is a clear connection with theme 4 (Climate proof cities). The urban effects of climate change, such as flooding, urban heat island effect are studies extensively in this theme. Indirect effects are one of the focus subjects in the theme, and some of those involved in WP2 of theme 8 are involved in theme 4 too; notably on the effects of heat and cold extremes on mortality, morbidity and productivity in cities. Informal talks have been held with participants from WP5 in theme 1, and there may be some possibilities of cooperation when it comes to analyses of flood risk management. So far concrete cooperation has thus been limited, but it is expected to be strengthened in the future.

C2 Contributions to Deltaprogramme or other national and international (e.g. EU programmes)

One of the main aims of this Work Package is to examine the consequences of individual level heterogeneity and deviation from rational decision making on macro level consequences of a flood. An analysis which incorporates such elements may yield very different results than more “traditional” analyses which disregard them. For example, empirical studies have found that the post-disaster migration return rate differs widely between socio-economic groups. In order to speed up recovery, optimal post-disaster recovery policies should take such issues into account. It is important that analyses used for policy recommendation incorporate heterogeneity.

The Netherlands is in a somewhat unique position in terms of flood risk and challenges for future flood policies. On the one hand, the current regime offers very high safety standards. On the other hand, its top-down structure creates little incentives for individual adaptation efforts. There is political interest in putting more emphasis on individual adaptation, but this is made difficult by low flood risk perceptions. The model proposed in this study would allow for investigating the effects of altered individual risk perceptions, and represents as such a novel approach. Another area where this WP contributes to the international literature is in the area of the long term effects of disasters. Empirical work carried out under this WP has found short term effects of the flood in 1953, but little long term effects. But the study did also find that the flood mitigation following the disaster had long term effects which may have served to increase exposure – a result in line with some recent theories in the economic literature.

D2 Research results for WP2

The ambitions and visions as formulated by the consortium were high, requiring both societal and scientific deliverables already in the first year. This has obviously been a challenge due to data availability and other technical challenges. However, the project runs as scheduled. The first societal deliverable, a literature review of the current state of modelling of natural disasters, was completed by Christmas 2010, and presented at a seminar at the IVM in January 2011. Subsequently, work with

compilation of a database used for the model began. A conceptual framework for the model was established and presented at the IVM in December 2011. In the fall of 2011 work with the empirical investigation of the historical effects of flood had also begun. A draft version was completed by March 2011, and some results from this study were presented at the workshop in Rotterdam in May 2012. The plan is to finish the work with the model by Christmas 2012, which is according to plan. Results from policy analyses are expected a year later. We expect some technical challenges regarding the implementation of the ABM-CGE model, as this is a novel approach. Model implementation of policy scenarios will also represent a challenge, but this is an area where particularly TNO has great expertise.

The main added value of this WP will be the formulation of the model, that will include elements that are novel in economic modelling. The literature review found that current economic models employed to assess the long term and indirect effects of floods are somewhat ill suited for analyses of such nonlinear phenomena as natural disasters. There is thus recognition in the existing literature of the need for modelling framework which takes heterogeneity and non-rationality into account. An additional added value comes from the empirical study which involved the construction of a database of municipal-level population figures in the Netherlands in the period 1900-2000. Here the municipalities were adjusted for territorial changes over the time-period, enabling for consistent analyses of the population development over time. The concrete output of this research is not only resonant with economic research which has investigated the impact of large temporary shocks; it also highlights some important issues for future flood risk management in the Netherlands. The opportunities for amplifying this added value lay mainly in how to connect the results with the current policy discussion. One key area where the added value can be amplified is in the discussion on flood risk. The current definition of flood risk is based on rather mechanical legal definitions and there is a growing recognition that these legal safety standards do not correspond to individual risk perceptions. The modelling approach aims specifically at incorporating the notion of risk perceptions, and as such, there is also a potential of contributing substantially to a more conceptual discussion on flood risk.

E2 Impact on society

Although contact with hotspots so far has been limited, it is expected that results from this WP are useful in a broader discussion about the long term flood management policies of the Netherlands. Furthermore, it is expected that results from policy simulations will be of interest to stakeholders due to the disaggregated approach.

Representatives for the WP did participate in an expert meeting organised by TNO and DHV in Rotterdam, where policy makers as well as participants from academia, research organisations and the insurance sector were present. Topics ranged from innovations within flood risk management to the economics of flood risk. The contribution from this WP, which focused on the interplay over time between flood risk mitigation and exposure, resulted in a lively discussion involving participants from different areas. From the discussions it became clear that the individual adaptation and perception of flood risk –a core topic of this WP- is of great interest to policy makers and others involved in the future of flood safety in the Netherlands.
One obvious challenge for this WP is that the work is of a rather technical nature during the process, meaning that most substantive discussions about research output mainly would take place towards the end of the project. Another challenge is to translate output into results suitable for a broader audience. But as the workshop in Rotterdam evidenced, some of the research questions under this WP can indeed spur fruitful discussions among non-academic stakeholders. The workshop showed the mutual interest in better figures for flood impact estimation.

F2 Conclusions and prospects

Within the consortium, research results as well as strategies for coming work have been communicated through regular meetings with the whole consortium, or parts of the consortium. The consortium consists of parties from different research organisations and some efforts have been made to make the cooperation within the consortium run as smoothly as possible. The cooperation between TNO and IVM is now well running, and currently the research cooperation with Deltares is being strengthened. External communication is mainly carried out through participation in workshops and seminars, reports to Knowledge for Climate, as well as (planned) publication of journal articles. The following deliverables are planned to be published as journal articles

- D2: Regional effects of floods based on historical data (draft version ready, uploaded to the KfC)
- D1: Methodology for integrating ABM and CGE approaches
- D4: Description of the extended RAEM-E3 and its first application
- D5: Results of extended policy analysis

The work package will provide in-depth insight in the secondary effects of flooding and this information will be used in future damage assessment.

WP3: Interactive development of spatial adaptation strategies

Work package leader: Dr. Ron Janssen (IVM-VU)

A3 Aim and approach of WP3

The main objective of the project is to develop implement and test a map based interactive environment for the design of adaptation strategies. Research questions will focus on effective use of information in a participatory workshop setting. Specific attention will be given to the development of heuristics to generate reference alternative, development of design and negotiation tools, negotiation strategies, improvement of the map as an interface and workshop design.

After reaching the limits of technical instruments adaptation and spatial planning have become increasingly interrelated. As a result land use change plays a central role in the development of adaptation strategies. However, it is also clear that national and provincial agencies face many difficulties in adjusting their policies in such a way that future land use changes get serious consideration. On the one hand, this may be related to the fact that the consistency of different (long term) policy goals have not yet received due attention. On the other hand, strong public resistance at local level against any perspective of near future landscape changes has created an atmosphere of deadlock. Policy makers seemingly face the dilemma between doing the right thing and doing it the right way, i.e. through consulting the public. A participatory approach which will involve a multitude of stakeholders may be successful in that the stakeholders will be able to identify and reflect upon several comprehensive strategies and assess, with the help of scientists, their specific impacts for policy areas such as climate change, water retention, nature conservation, agriculture and other considerations with respect to spatial planning.

Spatial adaptation strategies can be developed only in a complex process of interaction with a large number of stakeholders. A number of decision support systems have been developed to support water management. The use of these systems in participative decision processes has not always been successful (Geertman and Stillwel 2008). There are two main reasons: 1. the decision support systems are not well tailored to the needs of the participative process and 2. systems are often information driven, ignoring the process and human side of the use of these systems.

Within this project we describe the relevant decision processes and identify the information needs by the various stakeholders at different stages of these processes. We have developed interactive workshops to facilitate problem analysis, problem identification, design of management alternatives evaluation of alternatives and feedback to design. The project focuses on the development of spatial design approaches using a mixture of formal design routines, visualization techniques and structured feedback from participants in workshops. Techniques are integrated in a spatial decision support framework implemented in hardware suitable for interactive use in a workshop.

Within this project maps are used as the main means of communication. Since most people use reference maps, such as road maps, they are familiar with their use and are happy to use them as a source of information. In practice effective use of maps is a difficult task for many people. A task that becomes more difficult if the information density of the map increases and the direct link with reality gets weaker (Arciniegas et al 2010, Carton and Thissen 2009).

Spatial planning requires a combination of formal analysis and holistic design. In landscape design such as nature development in the river plains, the landscape architect plays an important role. Hand drawn maps go hand in hand with model output from hydrological models. Because the information load is high spatial decision support should complement design by the landscape architects.

This project integrates quantitative information on impacts of climate change and adaptation within the more qualitative process of spatial planning. We developed an approach that uses this information effectively to interactively develop adaptation strategies with multiple stakeholders with often

conflicting objectives. Maps are used to communicate and exchange knowledge among policy-makers and stakeholders.

Within this project we use an interactive mapping device (the 'Touch table') to support participatory planning workshops. The table is used in a series of workshops with the various stakeholders to generate, assess and discuss adaptation strategies for the case studies. The approach involves three types of workshops. The nature of each workshop is defined according to one of the three frames in the framework for map use in policy making (Carton and Thissen 2009).

- Analysis map a research model
- Design map as a design language
- Negotiation map as a decision agenda

Interaction between stakeholders is prompted through the use of maps, decision support tools and touch-enabled screens to support stakeholder collaboration and spatial information handling (Microsoft Surface, Map Table or Touch Table).

B3 Relations with other KfC themes

WP3 is closely related to the Themes 2, 3 and 7.

C3 Contributions to Deltaprogramme or other national and international (e.g. EU programmes)

The spatial decision support tools developed in this project are used within the three case studies that are part of the 'Hotspot Fen meadows and shallow lakes'. These case studies are the fen meadow polders of Zevenblokken, Tjeukemeer and Zegveld. Within these case studies the approach developed in this WP will is used to support actual spatial planning processes. The workshops conducted so far have shown that use of the tools improved effective use of spatial information and promoted stakeholder participation. The approach developed can be used to support design of adaptation strategies in other fen meadow areas. The underlying ideas have a much wider scope for application.

Experiences with the fen meadow projects have shown that finding a suitable case study is not that easy. Especially when stakes are high political constraints may well prevent researchers to be allowed into the process. In a later stage stagnation of the political process may pose difficulties for the project.

D3 Research results for WP3

After reaching the limits of technical instruments adaptation and spatial planning have become increasingly interrelated. As a result land use change plays a central role in the development of adaptation strategies. However, it is also clear that is that national and provincial agencies face many difficulties in adjusting their policies in such a way that future land use changes get serious consideration. On the one hand, this may be related to the fact that the consistency of different (long term) policy goals have not yet received due attention. On the other hand, strong public resistance at local level against any perspective of near future landscape changes has created an atmosphere of deadlock. Policy makers seemingly face the dilemma between doing the right thing and doing it the right way, i.e. through consulting the public. A participatory approach which will involve a multitude of stakeholders may be successful in that the stakeholders will be able to identify and reflect upon several comprehensive strategies and assess, with the help of scientists, their specific impacts for policy areas such as climate change, water retention, nature conservation, agriculture and other considerations with respect to spatial planning.

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E3 Impact on society

Three interactive workshops in the Netherlands illustrated the application of the spatial support tools for planned adaptation. On the Dutch Wadden Sea Island "Texel", drawing tools were applied to validate model results and to explore problems and opportunities for adaptation measures. They were easy to use and can be applied in multiple forms. For the second case study in "Zevenblokken", a simulation tool was available to design options for water management. The second workshop showed that a major requirement for interactive spatial tools is the opportunity to change spatial variables both directly and indirectly and analyze both individual and multiple impacts within a limited calculation time. In "Friesland", an evaluation tool was used to compare different water management alternatives. In all three case studies, spatial support tools were tailored to the regional context. Interactive spatial tools provide access to a collection of best available data for a specific region. Workshop results showed that interactive participation promotes stakeholder involvement and encourages knowledge exchange and acceptance of adaptation options. Before actually using spatial tools, participants prefer to test them. As suggested by the experience from the case studies, complexity of tools has to be minimized and transparency maximized. Similar conditions for effective adaptation were found by Füssel (2007). The results of this study agree with the suggestion of Opdam (2010) that communication between

science and society is valuable for planning. The suggestion for future research is to continue the collaboration between science and society in both the development and evaluation of interactive spatial support tools. Knowledge transfer is a primary target and is achieved through direct involvement of stakeholders in the planning workshops.

F3 Conclusions and prospects

Workpackage 3 is developing according to the scheduled plan and we envisage to apply the method is several other case studies. In this manner the workpackage will not only contribute to scientific development trough improving the methods for interactive development of adaptation options but also to the practical implementation of adaptation in a variety of settings in the Netherlands.

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WP4: Visualization and simulation of impacts and strategies

dr. H. Goosen / prof.dr.ir. G.S. Stelling/ dr. Ir. Gerwin de Haan

A4 Aim and approach of WP4

The goal of WP4 is to provide novel state-of-the-art visualization tools and guidelines. It is very important to include end user needs and requirements in the development of decision support tools. WP4 includes a variety of stakeholder groups to specify their needs and requirements and the project develops a theoretical framework to better match visualization needs with the various possible frames that stakeholders possess. The project uses desk top study results from case studies via the consultation with stakeholders and policymakers. The main research question is how interactive visualization and simulation systems for various types of target group directed protection measures contribute to the use of climate change information in planning for regional and local adaptation strategies. This project concerns three subprojects, namely Project 1 (Visualization for decision support in adaptation planning), Project 2 (interactive simulations of water flow in inundation and rainfall scenarios) and Project 3 (interactive visualization of geo-data and real-time simulation results).

B4 Relations with other KfC themes

The projects within the work package are interlinked, but the work package also has important links with other work packages within the overall thematic proposal. There are also connections to other thematic projects (the other KvK themes), and with research and assessment activities outside the 2nd tranche of the Knowledge for Climate program.

Links between the projects within WP4:

- The 3D visualizations and water simulations developed by the TU Delft for the Haaglanden hotspot (projects 2 and 3) will be evaluated in the 'Development, application and testing visualizations for knowledge transfer in adaptation planning' project (project 1). The effectiveness of the 3D visualizations will be evaluated and it serves as an important case study in this work package.

Links within the overall project

- Links with WP3 (interactive design): WP3 develops an approach for interactive development of adaptation strategies. Maps are used to communicate and exchange knowledge among policy-makers and stakeholders. WP 4 will develop visualizations that will be used in the interactive design process. The series of interconnected workshops of WP 3 will be used as test cases to measure the effectiveness of the visualizations.
- Links with WP 7 (Indicators): Visualization can be used to communicate the performance of adaptation strategies on vulnerability and adaptation indicators. Hence close collaboration with WP7 on indicators will be ensured.

Links with other KvK projects

- Visualizations are in theory relevant to all of the KvK themes and research projects. The Climate Effect Atlas is a KvK project which attempts to capture and disclose relevant knowledge form the various projects (within and outside the KvK program). The Climate Effect atlas will play a central role in both work package 3 and 4 and will safeguard a close connection to ongoing KvK research.

Links with other research

- In the domain of GeoVisualisation there are links with the VISCOM project [10], visualization of aerosols [4] ,previous experiences within the PSPE project [5], making use of the PEER-METIER network on geo-visualization [6] and on both ICA networks on visual analytics and on usability [7].
- In the domain of user impacts there are relations with studies on understanding user groups and their perception of environmental changes [8] and their perception of maps/3D scenes in relation to spatial awareness [9], [10]

There is also a link with the research project “the role of visualization in environmental impact assessment, Kenia”
Project 1 contributes to the theoretical understanding of framing perceptions on adaptation planning and the use of visualisation methods and techniques for depicting uncertainties of spatial impact information at the local scale. Both the usability of the framework of De Boer et al (Wardekker, de Boer et al. 2009; de Boer, Wardekker et al. 2010; de Boer 2012) and the graphic variables of Bertin (Bertin 1983) are investigated and elaborated. As a first result, visualizations were developed and tested for the Urban Heat Island effect in the area of Haaglanden, resulting in nine Urban Heat maps. Different visualisation techniques were used. During a stakeholder workshop these were resented and tested.

C4 Contributions to Deltaprogramme or other national and international (e.g. EU programmes)
The research proposal of project 1 has been reviewed by international research partners. The Wageningen research group has a close collaboration with prof. Stephen Sheppard (CALP group, Canada). Project 2 collaborates with the RWTH Aachen Virtual Reality Group, headed by prof. Torsten Kuhlen. Part of the work in WP4 will be carried out by a postdoc researcher and a PhD student. who will work at RWTH Aachen for a period of time during the project. They will work there mainly on the computational steering user interaction for an integrated simulation and visualization system.

D4 Research results for WP4
The work package visualizes scientific information on climate change impacts to different target audiences. The project is not so much targeted at contributing to the basic science behind climate change, it rather attempts to better communicate scientific information about the effects and impacts of climate change. In our experiences in the different workshops, we found that these visualization techniques are extremely helpful in better understanding the possible consequences of climate change. The Urban Heat Island workshop in Haaglanden raised awareness of this phenomenon among the stakeholders in the region. As a first result in Project 2, a prototype software system has been developed for interactive 3D visualization of very large 3D geographic data sets. Raw scan data from the new "Actual Height Database of the Netherlands" (AHN2) are used, in which both the large-scale landscape data and 3D structures such as vegetation and buildings are included in great detail. The visualization shows a realistic and complete picture of the landscape in 3D. The specific data and software structure guarantee a smooth image on the screen, which allows interactive navigation through the 3D landscape. Our initial integration with Sobek numerical flooding models integrates animation of various flood scenarios, e.g. due to extreme rainfall, including realistic visualization of waves and ripples to depict the flow direction of the water flow. The first demonstrations to domain experts and laymen indicate that this facilitates easier insights in scenarios and decisions. At the simulation part (Project 3), we were successful in implementing a new "subgrid" data structure to significantly accelerate simulations (over 10 times of previous methods), up to a point where they become interactive to control. The research prototype allows interactive addition of rain and run-off simulations, and is being extended to include dynamic changes in the landscape such as making a breach in a dike. For the projects 2 and 3, the indicated deliverables have been met, and in the remainder of this project we focus on full integration between real-time 3D visualization and simulation, and embedding within case studies. We aim to further increase and evaluate usability of these techniques, enhance visualization techniques for improved information and communication value, and investigate the integration of other types of 3D GIS and landscape data and assess system scalability.

E4 Impact on society
The Hotspot Haaglanden is one of the case study areas within Theme 8. In November 2011 a workshop with policy makers of the different municipalities, the Province and the Water Board was held. Aim of the workshop was to identify the main issues for Urban Heat Island effect and urban development. Based on temperature measurements for Rotterdam (results from Climate Proof Cities,

theme 4) a correlation between the urban density, building height and green areas was found (Heusinkveld, Koekoek, 2011). Within WP4 visualizations were developed combining the UHI effect with social-economic development scenarios (result of WP1 within this theme) and the climate scenarios of the Royal Dutch Meteorological Institute (theme 6). This is a good example of how WP4, as a cross-cutting research activity, can help to integrate and communicate scientific results from various themes and work packages. The figure below shows one of the visualisation techniques used to express such amount of information for the city of The Hague. During the workshop we have presented and tested some other techniques.

Projects 2 and 3 are conducted as a part of the project "3Di Water Management", in cooperation with the Waterboards of Delfland and Hollands Noorderkwartier, Deltares, Delft University Civil Engineering, Waterkader Haaglanden, and Nelen and Schuurmans (a private consultancy firm in watermanagement). Within this project, the emphasis is on development of simulation and visualization tools for scenario exploration for decision support in water management. Results of the investigation can be evaluated on the basis of practical problems, and usability of the tools can be examined. Within the 3Di project, the current research prototypes are extended by Deltares for practical application at stakeholders. The software system is suitable for large-screen stereo projection for increased the visual impact and spatial insight. Also, a mobile stereo projection setup was built for demonstrations and case studies. The first results of static flooding scenarios have been frequently demonstrated to stakeholders and domain experts, including the "Deltas in Times of Climate Change" conference held in Rotterdam. Already in November 2010, a first evaluation of the system and

visualization was performed in an emergency exercise with the Waterboard of Delfland, the City of Delft, and local emergency services. Several other case studies, also for the Hotspot Haaglanden, have been applied with this system since.

F4 Conclusions and prospects

The work within WP4 is a good example of a cross-cutting research activity, that aims to integrate and communicate scientific results from various themes and work packages. Land use modelling (WP1) was combined with state of the art Urban Heat Effect modelling (Climate proof Cities, theme 4) to create innovative visualizations that were presented to the stakeholders in the Hotspot Haaglanden in a workshop in november 2011. Visualization tools for scenario exploration for decision support in water management result from the activities in projects 2 and 3. The first results of static flooding scenarios have been frequently demonstrated to stakeholders and domain experts, including the "Deltas in Times of Climate Change" conference held in Rotterdam. Already in November 2010, a first evaluation of the system and visualization was performed in an emergency exercise with the Waterboard of Delfland, the City of Delft, and local emergency services. Several other case studies, also for the Hotspot Haaglanden, have been applied with this system since.

New PhD student Christian Kehl will focus on the tight integration between 3D visualization and simulation environments, which also allows for more acceleration of simulations by making use of hardware-acceleration on graphics cards. We envisioned collaboration with WP3 (Interactive development of spatial adaptation strategies), potentially collaborate on the Friesland case study for water management in using real-time simulations to assess design options in interactive adaptation sessions. Finally, together with the HPCV-center from RUG Groningen, our WP team received shared 3rd price in the national "Enlighten Your Research 3" contest, organized by Surfnet and NWO. This includes support to use national e-infrastructure such as data storage, cloud-computing and networking, which we will allow us to further improve on the distribution of our visualization and simulation results, and bring them more easily to adaptation planning sessions.

WP5: Economic modeling and assessment of the impacts of climate change and adaptation strategies on freshwater resources

Work package leader : Prof.dr. R. Brouwer (VU-IVM)

A5 Aim and approach of WP5

Climate change has important implications for the stock and flows of freshwater resources in the international river basins to which the Netherlands belongd. A significant share of the Dutch economy depends on the availability of these freshwater resources, and hence what happens in an international River basin context may significantly impact sectors in the Dutch economy. Previous studies examining the allocation of limited freshwater resources under scarcity conditions, such as the 'Droogtestudie', can be characterized as partial, single sector oriented, driven by hydrological models, and focusing primarily on the direct financial implications of water use restrictions. There is a need for a more integrated, multiple-sector, dynamic hydro-economic model. Such a model is not available in the Netherlands. This model should include sufficient economic rigor and regional detail to assess the wider direct and indirect economic impacts of implementation of national water policy as laid down in, for example, the National Water Plan and institutionalized water allocation decision rules under scarcity conditions. The main objective of this work package is to develop such an integrated hydro-economic model at international river basin scale. This model will support policy and decision-making towards economically efficient water allocation across different water users and river basins whilst accounting for the shadow prices of scarce freshwater resources. This also provides the basis for the design of possible future water markets.

Central research questions of this WP are:

- How efficient are current freshwater resources allocation decision rules across sectors and regions in the countries that are part of the international river basins of the Rhine and Meuse from an economic point of view?
- What are the economic implications of future climate change scenarios on the freshwater resources allocation across sectors and regions in the countries that are part of the international river basins of the Rhine and Meuse?
- How can economic efficiency of freshwater resources allocation be improved across sectors and regions in the countries that are part of the international river basins of the Rhine and Meuse given future climate change through cost-effective adaptation strategies?
- What role is there for economic markets to improve freshwater resource allocation efficiency across sectors and regions in the countries that are part of the international river basins of the Rhine and Meuse given future climate change?

In order to answer these questions, the GTAP model will be used, a global computable general equilibrium model, which is characterized by different regions, and specified for the Netherlands, Germany, Belgium and France.

B5 Relations with other KfC themes

There is a clear connection with theme 2: Climate Proof Fresh Water Supply. This link will be further explored in the second half of the project once the model's prototype is ready.

C5 Contributions to Deltaprogramme or other national and international (e.g. EU programmes)

The preliminary results of the project were shared with the Dutch "Deltaprogramma Zoetwater". The WP leader conducted an exploratory study on the usefulness of economic policy instruments for freshwater resources management in the Netherlands together with the "Waterdienst Rijkswaterstaat". The results of this study were presented during a one-day stakeholder workshop at the Bouwdienst Rijkswaterstaat in Utrecht in November 2011.

D5 Research results for WP5

The scientific discussion related to transboundary water allocation and distribution policy is dominated by bottom-up hydrological and in some cases also hydro-economic models, where partial equilibrium economic demand functions are linked to existing water extraction points across a river basin. The application of general equilibrium macro-economic models to water allocation and distribution issues is very limited (e.g. Berrittella et al., 2007; Brouwer and Hofkes, 2008; Calzadilla et al., 2010 and 2011). The main advantage of the latter type of models is the ability to model both the direct and indirect effects of water policy interventions on the economy as a whole. This research project starts from the economic system in addressing water allocation problems in a transboundary river basin context. This is to our knowledge the first transboundary application of a computable general equilibrium model to water allocation and distribution.

This is a very ambitious WP. A lot of time and energy had to be invested in the conceptual design of the modelling framework. Key challenges included the regionalization of the macro-economic model. The existing GTAP-W framework was reworked into a modelling frame for the international Rhine and Meuse river basin countries: the Netherlands, Germany, Belgium, and France. Achieved results include a significantly better understanding of the model structure required to address the research questions listed above. The work carried out so far is currently converted in the first journal paper. This journal paper will be ready before the end of the first year (15 September 2012), and focus on the model structure and first climate change simulations compared to the baseline reference in the year 2005.

The main added value of this WP will be the delivery of a model instrument that allows the Dutch government to assess the economic efficiency of current and future water allocation procedures like the “verdringingsreeks”, taking into account water scarcity conditions due to climate change. The model will help to support and justify water allocation policy based on economic efficiency considerations of the shadow price of water in different economic sectors in the Dutch economy. The model will furthermore provide an important stepping stone and the basis for future design of possible water markets.

E5 Impact on society

Although contact with hotspots so far has been limited, it is expected that results from this WP will become more useful once a prototype of the model is available that can be used in a broader discussion about the water scarcity and allocation management policies in the Netherlands. The model that is being developed will be useful at national and international scale. Furthermore, it is expected that results from climate change policy simulations both in the Netherlands and neighbouring river basin countries will be of interest to a wider set of policymakers and stakeholders.

F5 Conclusions and prospects

Within the consortium, research results as well as strategies for coming work have been communicated through regular meetings with the whole consortium, or parts of the consortium. The consortium consists of parties from different research organisations and some efforts have been made to make the cooperation within the consortium run as smoothly as possible. In this WP, IVM collaborates primarily with Prof. Richard Tol (University of Sussex), Dr. Alvaro Calzadilla (Kiel Institute for the World Economy), Prof. Katrin Rehdanz (Christian-Albrechts University of Kiel), and Deltares. Collaboration is most intensive with Prof. Tol and Dr. Calzadilla. Efforts are under way to also further strengthen collaboration with Deltares, in particular through the examination of existing climate change scenarios developed among others at Deltares and existing sectoral water use models.

External communication is mainly carried out through participation in workshops and seminars, reports to Knowledge for Climate, as well as (planned) publication of journal articles. The following deliverables are planned to be published as journal articles:

- Description of the methodology for modifying GTAP-W to the international river basins of Rhine and Meuse, including a first model application (scenario simulation).

- Analysis and simulation of the 1967 and 2003 droughts in the Netherlands, examining optimal water allocation under economic efficiency conditions, compared to actual water allocation decisions in the respective years.

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WP6: Optimal timing, cost benefit analysis and adaptation strategies

Work package leader: Prof. dr. E.C. (Ekko) van Ierland (WUR-ENR) in close cooperation with Dr. H-P Weikard

A6 Aim and approach of WP6

The project aims at developing detailed methods that can be applied in various case studies in a consistent manner, considering the future climatic change, based on the scenarios of KNMI and other meteorological offices. In close cooperation with the hotspots, it will be identified what type of assessment (CBA, MCA or qualitative methods) is required and what level of detail will be applied and what will be the relevant discount rates and CBA categories to be included in the analysis. We will focus on no regret options and precautionary measures and develop a clear set of guidelines on how to make assessments in a practical setting, based on the OEI framework for CBA but extended to cover issues that are particularly relevant for climate adaptation, such as irreversibilities and reservations for future actions. Special attention will be given to resilience and robustness, with linkages to PhD projects envisaged by Deltares in KvK Themes 1 and 2. The project will particularly be linked to the hotspot Haaglanden and will contribute in close cooperation with the stakeholders to the development of the regional adaptation strategy for Haaglanden.

Research questions

How can optimal timing of adaptation measures be determined in a setting of decision making under uncertainty and what are the implications for developing a adaptation strategy for climate change at the regional level?

Methods

The work package will specifically focus on the optimal timing of adaptation options and discounting of costs and benefits of adaptation under uncertainty, in a setting where overtime more information is becoming available on the expected climate impacts and on the best options to adapt. This calls for flexible systems that allow for adjustment in later years. This flexibility however, often comes at a cost and these costs need to be balanced with the uncertain benefits that are provided by choosing a flexible strategy.

In the project we will elaborate the theoretical framework, based the real option theory (cf. Pindyck (1994)) and we will apply the framework in a set of cases related to hotspot Haaglanden, where the costs and benefit structure will be analyzed in detail.

An important topic in this respect is flooding as a results of excessive precipitation in a setting where insufficient storage capacity is available because of the very intensive land use in the western part of the Netherlands. Because of the greenhouses of horticulture insufficient drainage is occurring and regularly flooding of greenhouses with high damages to agricultural production occur. Climatic change is expected to intensify this tendency and adaption measures for water storage and additional removal of excess water are required. This involves investment and one of the issues is the optimal size of these investments and the timing of the actual implementation of the investment program, and the adjustment of the program if new information on the impacts of climatic change becomes available.

A specific issue in the project will be how to deal with ancillary benefits that often have public good characteristics, such as benefits related to nature conservation and biodiversity. In traditional CBA these elements are often covered by pro memoria (pm) entries, which do not provide any information on the scarcity or the economic values involved.

B6 Relations with other KfC themes

Work package 6 is closely related to Themes 1,2,3,4,5,6 and 7 of KfC. The work package deals with decision making under uncertainty for flooding, inundation, urban heat islands and many other

adaptation options. Results are integrated in regional adaptation strategy for Haaglanden and is closely related to governance issues. Links are expressed through regular meetings and joint participation in workshops.

C6 Contributions to Deltaprogramme or other national and international (e.g. EU programmes)
This work packages is fully relate to the EU-funded Mediation programme in which all leading research institues in Europe cooperate on adaptation to climate change. We also directly provide in put to the Delta programme through regular consultations with the economic experts of the Delta Commisariaat in the Hague.

D6 Research results for WP6
We are currently addressing the following research questions:

Paper 1: Efficient dike height revisited: cost minimisation under an unknown rate of the water level increase and with the possible arrival of new information

1. What are efficient dike heightening strategies under uncertainty and uncertainty resolution regarding the rate of the structural increase of the water level?
2. How do these solutions compare to previous results?

Paper 2: Conditions for local over-compliance with national standards to prevent surface water inundation anticipating climate-change induced legislation change

3. Under which conditions is strict compliance with national surface water inundation standards (1/10-1/100 'werknormen') at the local level optimal?

Paper 1 encompasses the analysis of optimal dike heightening under a single source of uncertainty and (perfect) learning. Dike heightening is an expensive activity in absolute terms and a thorough understanding of the problem is therefore relevant in order to maximise social welfare. It is likely that better information on climate change impacts will become available as time series grow longer and research progresses. The question is how we could and whether or not we should anticipate future information arrival. The draft paper has been attached. The work continuous on follow-up work of Eijgenraam (2005), Eijgenraam (2006), Den Hertog and Roos (2009) and Eijgenraam et al. (2010) which we extend with a probabilistic rate for the structural increase of the water level, and perfect uncertainty resolution at some unknown time. One may feel perfect learning to be an extreme assumption; next to the demonstration of how future learning interacts with today's dike investment, the sensitivity analysis shows that the numerical results also have a broader validity in the more realistic context of gradual learning. We find that anticipating new information results in lower and/ or later dike heightening compared to an inflexible strategy, and we also find that total expected costs have been systematically overestimated because of the value of information. Cost savings for dike ring 15, for instance, are in the order of 8.9 mil EUR (1.6% of total costs) when compared to a fully non-flexible solution, or 3.3 mil EUR (0.6%) when (more realistically) compared to an optimal response to information only. In general, the research highlights that non-flexible (multi-period) dike heightening strategies are an artifact. The numerical results should be interpreted with care as they are highly sensitive to distributional assumptions (learning probabilities, structural water level increase) and discount factors. In any case, under a reasonable degree of uncertainty (spread) the optimal dike heightening strategy is changed if the probability of learning in the future is non-zero, see Figure 1.

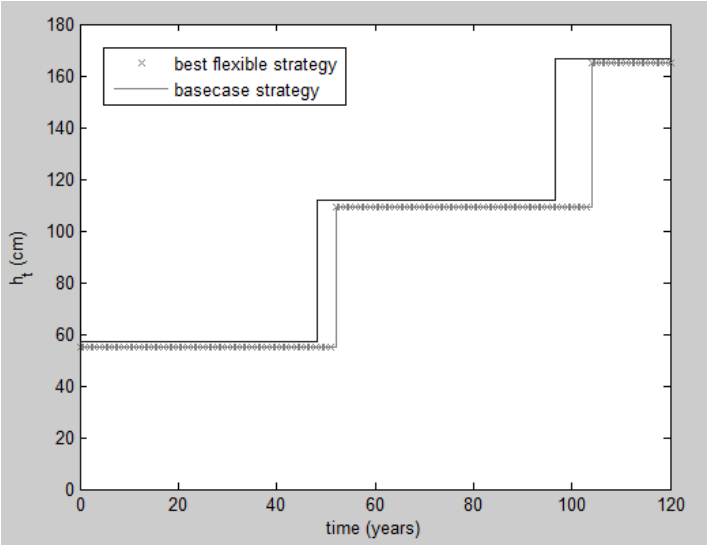

Figure 1 Optimal dike heightening strategy for ring 15 with stochastic learning (the conditional time of learning is assumed to be uniformly distributed, 37% of no learning at all), initial extreme water level uncertainty (normal, standard deviation 0.12 cm/year) and discount rates of 4%.

Paper 2 focusses on local compliance with the surface water inundation standards (1/10-100 'werknormen') with which water boards have to comply (see National Governance Agreement Water). Uniform standards have been formulated on the basis of cost studies. From these standards tasks are derived on the local level (storage, retention, drainage). On the basis of the defined tasks measures are identified in cooperation with all involved stakeholders, measures are selected and finally, when a polder is prioritised, implemented. This is summarised in Figure 1 below.

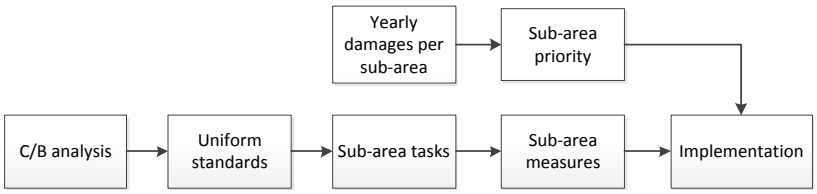

Figure 1 Current practice to select measures and determine the implementation order of measures taken at the local level.

Interestingly, the standards are introduced as 'golden rules' triggering strict compliance by local authorities. However, local authorities have local knowledge on the cost structure of measures but they seem to be unaware that these standards may change over time. According to the standards at least the 'middle' climate change scenario should be anticipated, but under which conditions would it be better for local authorities to over-comply? To understand when it is better to strictly comply and when it is better to over-comply at the local level we have to model possible legislation change. In this paper, we take a rainfall data approach as driver for legislation updating. We account for natural variability (we simulate yearly maxima), for distributional uncertainty (we bootstrap from the original rainfall data series to get a distribution for the rainfall distribution parameters), climate change (we interpolate the structural shift of the distribution) and we link significantly different return periods to legislation change. As a case application we intend to evaluate whether the recently created storage capacity in the Waalblok polder is of the right size. Delfland Waterboard has provided cost information to facilitate the analysis. The methodology is summarised in Figure 2.

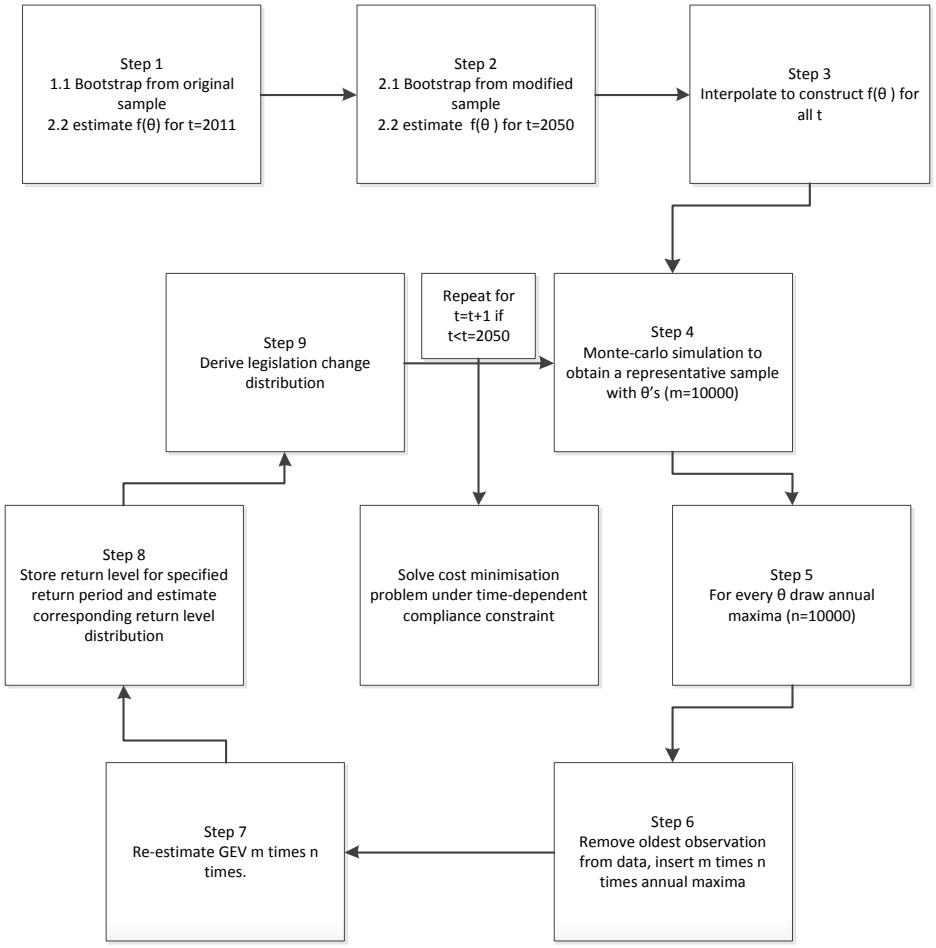

Figure 2 Summary of the methodology.

We aim for scientific publications to communicate methodologies, mechanisms and numerical results to the scientific community.

A primary objective of the research is to raise awareness about the concept of anticipating future information rather than merely recognising that the future is uncertain. Whereas in finance it is well established to price derivatives with processes for price change in contrast the governmental use of real option methodologies is very limited. The first paper is of a more theoretical nature, which is methodologically interesting as it demonstrates the mechanism of obtaining new information on investment size and scale. It furthermore gives an indication of the size of the effect of learning in the context of dike heightening which may be used in a policy arena to determine whether or not receiving new information in the future should be considered to determine current safety standards. Also, it contributes to more general discussions with respect to discount rates and modelling uncertainty and uncertainty resolution. The second paper addresses a fundamental question: how may standards change when this change should be based on observations? When such a process can be identified costs can be minimised for very concrete investment decisions taken at the local level.

E6 Impact on society

We contribute to the efficient allocation of scarce resources and are closely related to the Hotspot Haaglanden and the Deltacommisariaat as an advisor on economics.

F6 Conclusions and prospects

Work package 6 is developing well and produces novel results on the optimal timing of adaptation measures in a context of uncertainty. The research focuses on dike heightening and excessive precipitation and produces results that are also relevant to other adaptation measures. We expect to complete the PhD thesis, to publish at least 4 papers in the international journals and to produce novel insights on how to efficiently adapt to climate change.

WP7: Monitoring and evaluation

Workpackage leader: Kaj van de Sandt, Judith Klostermann, Jelle van Minnen en Leendert van Bree

A7 Aim and approach of WP7

The objective of this project is to identify or develop instruments and indicators to monitor and evaluate the implementation of adaptation measures and the climate-robustness of plans, programs and projects, at different spatial scales and in different phases of the adaptation policy cycle.

The following research questions will be addressed:

- Which evaluation methods and associated indicators are available or can be developed to monitor and evaluate the implementation of adaptation measures and the climate-robustness of plans, programs and projects?
- How does the choice of methods and indicators depend on the scale of application, on time, and on the specific policy objectives?
- What is a coherent framework to structure evaluation methods and indicators in the broader context of sustainability?
- How can monitoring and evaluation methods and indicators of climate change adaptation and climate resilience best be integrated into existing monitoring programs?
- How can indicators be communicated and visualized, taking into account uncertainties (with Work Package 4)?

Addressing all aspects of all questions equally and at the same time combining long-term research objectives with short-term policy support activities will be beyond the scope of the project. Currently, national and regional strategies are in the early phases of development, and monitoring and evaluation questions are expected to increase in the years to come. Therefore the final focus in terms of key sectors will depend on the choice of case studies which will be determined in the first phases of the project in consultation with national and regional stakeholders - the expected emphasis will be on water management and spatial planning. Similarly, not to exclude options at the start of the project, also the choice of tools and indicators for further elaboration will be made in consultation with the stakeholders.

B7 Relations with other KfC themes

By its nature the work package is directly related to all other Themes of KfC, because in all other themes the issue of monitoring and evaluation is relevant. Through the Hotspot Haaglanden the work can be applied in the context of the adaptation strategy for Haaglanden.

C7 Contributions to Deltaprogramme or other national and international (e.g. EU programmes)

The work package is directly related to the EU funded programme MEDIATION.

D7 Research results for WP7

Adaptation to climate change has become increasingly important in the discussion on how to manage caused by climate change. Even if mitigation strategies become successful in the coming years, it is widely recognised that climate change will continue for years, decades and even centuries. Climatic changes are expected to have a severe impact on the environment and society by impacting important sectors, such as the transport sector, the water sector, the health sector, the agricultural sector and the coastal areas. At the same time positive effects are possible in some sectors like agriculture in some regions and under limited climate change. In order to cope with these impacts adaptation policies and measures are developed and implemented. Still adaptation is in the early stages of the policy cycles. Until now little thought are given on how climate adaptation can be monitored and evaluated. Monitoring the progress and outcome of adaptation policies and actions is important to:

- Justify, target and monitor funding for adaptation
- Mainstream adaptation within and between sectors
- Communicate adaptation to policy and decision-makers and other stakeholders
- Compare adaptation achievements across sectors, regions and countries
- Inform international climate change negotiations
- Learn from and improve adaptation initiatives

Analyses of existing monitoring frameworks
At national level many European countries have formulated an adaptation strategy. Despite these developments, climate change adaptation is a relatively new field. So far there is little tangible experience on monitoring and evaluating adaptation policies, measures and actions. To monitor the adaptation process and its outcomes, indicators and monitoring frameworks are being developed by a number of European institutions to monitor the adaptation process and its outcomes. Initiatives to monitor and evaluate National Adaptation Strategies are undertaken in the England, Scotland, Germany, Finland and France. Looking into these initiatives important lessons can be learned for developing monitoring systems:

- Both process-based and outcome-based indicators are needed to monitor the progress of adaptation and its outcomes
- The choice of a monitoring method, indicators and procedures follows the objectives of the evaluation
- Types of indicators depend on the clarity of the strategy, policies and the aspirational goals.
- The choice for indicators depends on the spatial and temporal scale of the adaptation policy, project or strategy
- Because adaptation must address multiple hazards across multiple sectors, a large set of indicators will be needed to provide the big picture. It is impossible/unnecessary to capture the entire field. It will therefore be a challenge to prioritize, combine or aggregate indicators to give an overall picture of adaptation. Criteria for prioritization are needed in this context.
- There is a need for additional contextual information. Currently it is still difficult to identify precise and robust outcome indicators of adaptation. Therefore proxies are often used as outcome indicators. To make them really useful/applicable contextual information is needed on social, spatial, temporal factors. This is needed to understand, for example, the relation between adaptation and the driver(s), the cross-sectoral dependencies, how adaptations relate and interact with other indicators and the acceptability of adaptation for stakeholders.
- Stakeholder participation is important to agree on goals, focus and vision
- Data availability and quality issues must be addressed/guaranteed
- Assess what additional communication and action may be necessary to augment indicator information so that it is meaningful to practitioners, as well as to policy-makers.
- Adaptation takes place over a long period. Adaptation needs to keep abreast of relevant developments (e.g. national and regional scale, and in sectors) and assess how these might best be of value.

Adaptation monitoring and indicator frameworks are known to encounter some problems. In climate change policy there often is uncertainty about cause – effect relations and about the preferences among stakeholders regarding possible outcomes. This makes both defining common adaptation goals and attribution of the effect to adaptation action difficult. The IPCC defines adaptation as adjustment in natural or *human systems* in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. Various types of adaptation can be distinguished, including anticipatory, autonomous and planned adaptation Reducing vulnerability can be done by reducing exposure and sensitivity or by increasing resilience and adaptive capacity. Most

work has been done on climate impacts, little attention is given to monitoring of adaptive capacity. Finally, adaptation is often implemented by mainstreaming it into other policy domains. It is advisable to integrate the indicator framework with existing monitoring activities. For example, it can be assessed if existing sectoral indicators can be used as adaptation indicators.

It is important to initiate discussions between scientist, policy makers and stakeholders that are developing and/or using adaptation indicators to clarify their development and use, and to minimise the differences between frameworks. The European union can organize this discussion at the European scale and national governments can take this role at the national level.

Adaptive monitoring

Adaptation to climate change takes place over long time periods and deals with uncertainties. In the coming years insights on climate adaptation and climate impacts will increase, although the knowledge will never be complete. Monitoring systems and the use of indicators need to be flexible in order to incorporate these new insights. Adaptive Monitoring is a concept that support this flexibility. An adaptive monitoring program is one that can evolve in response to new questions, information, situations or conditions. However this must not distort or breach the integrity of the data record (Lindenmayer and Likens, 2009). A fundamental part of adaptive monitoring paradigm is the iterative character of the monitoring activities. This means that the monitoring system is flexible and can evolve and develop in response to new information and questions. Adaptive monitoring allows for changing the initial question when this question has been answered, or when new questions need to be posed (Lindemayer and Likens, 2009). This means that adaptive monitoring is a cyclical process aimed at learning. At the end of every evaluation the monitoring system is questioned in order to improve the system (also known as 'double loop learning').

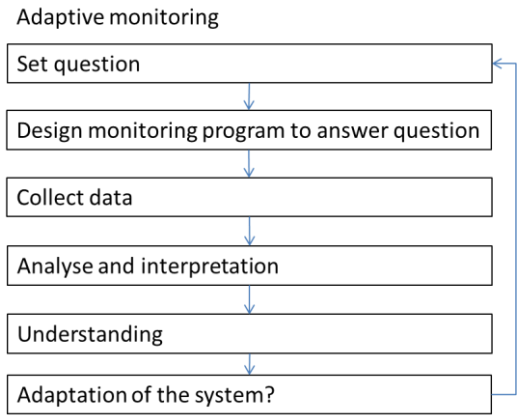

Figure 1 The framework of adaptive monitoring (Lindemayer and Likens, 2009)

The consortium started this year with a literature review on existing monitoring strategies across Europe. The literature study aims at giving an overview of the knowledge and practise on adaptation monitoring. The results of this analysis will be used to define important elements for developing a framework for adaptation monitoring. This framework does not lead to a 'one size fits all' solution for adaptation monitoring. Adaptation projects simply vary too much. The framework will guide one through the important aspects of the monitoring of climate adaptation and selecting the indicators. The analysis is described in an informal note (June 2012). On the basis of this analysis Jelle van Minnen, Mike Harley (AEA), Willem Ligtvoet (PBL Netherlands Environmental Assessment Agency) and Kaj van de Sandt contributed with a chapter on monitoring to the new adaptation book: "The Routledge Climate Change Adaptation Manual - Lessons learned from European and other industrialized countries". This book will published by the European CIRCLE project and will be edited by Andrea Prutsch, Sabine McCallum (UBA_Vienna), Torsten Grothmann (PIK), Rob Swart (WUR) and Inke

Schauser (UBA-Dessau). We aim at writing an article about the monitoring framework in the summer of 2012. The book chapter and the informal note form the basis of this article.

E7 Impact on society

We will work on developing a framework for monitoring in the summer of 2012. This framework will consist of both process as outcome based indicators. The outcome based indicators will aim to measure different aspects of the adaptation goals through vulnerability (exposure, sensitivity and adaptive capacity). The role of temporal and spatial scales will be assessed. We will use the adaptive capacity wheel (Gupta, 2007) for analysing adaptive capacity. We will also work on criteria to prioritize indicators. Since it is impossible to capture the entire field.

We will work both on developing indicators and on developing the process around adaptation monitoring. Stakeholder participation is an essential part. More specifically we will work on how the process of adaptation monitoring should be shaped in order to ensure adaptive monitoring. Through integration of our approach with the Hotspot Haaglanden we will have a direct impact on the development of the regional adaptation strategy for Haaglanden.

F7 Conclusions and prospects

Due to illness of the project leader and personnel changes work package 7 had a delayed start. The team started not before the fall 2011. Personnel capacity has been made available to do the work within shorter time span and finish in 2014. The objectives of the study have not changed. The consortium consists of Kaj van de Sandt , Judith Klostermann (both WUR), Jelle van Minnen, Leendert van Bree and Nico Pieterse (all three PBL Netherlands Environmental Assessment Agency).

The consortium aims at the development of a monitoring framework for adaptation and will apply this framework on two case studies in the Netherlands. The central case study area Haaglanden is selected and the first contacts have been made. The coming period the consortium will discuss policy needs for Haaglanden and will develop a monitoring strategy based on the adaptation strategy and action taken in Haaglanden. We will also look into data availability and quality. Another case study still has to be selected.

The case studies provide information on the applicability of the adaptation framework. We will use the case studies to test and improve the framework. The case studies will provide important information on stakeholder participation, the gap between policy goals and indicators and data availability and quality. We aim to write an article about developing a monitoring strategy within a case study.

5. Conclusions and prospects: Decision Support Tools

The programme is well on schedule and we have already obtained interesting research results in several of the WPs.

WP1 The programme is very actively contributing to the development of new spatial scenarios for the Netherlands and is moving from 2D representations to 3D representation for the built environment. Many applications are ongoing, for instance for urban heat islands in Haaglanden but also for other regions of the Netherlands, e.g. Vechtstreek. The members of the team are leading in the development of scenario models for spatial planning and climate change.
WP2 is contributing to a detailed analysis of the secondary impacts of flooding particularly related to migration. Although the project has not yet generated hardcore results the PhD project is well on schedule.

Wp3 is dealing with interactive policymaking for spatial adaptation and has been very active in workshops at the regional level to search for better spatial configurations. New methods in visualization and interactive decision making are very promising and given the additional pressure on landuse and spatial competition we expect that the approaches will become more important in future policymaking, not only in the Netherlands, but in many regions of the world where competing claims on natural resources and land will become more pronounced.

Wp4 is producing very good results on visualization of various aspects of climate change, for instance for inundation at the very detailed level and in real time, and for urban heat islands for various scenarios for climate changes and urban development.

WP5 is innovating in the search for robust and resilient fresh water provision under climate change and makes a link between hydrological and economics aspects.Relations with the hydrological institute Deltares are well established by now.

WP6 is analyzing decision making under uncertainty for excessive precipitation and for the risk of flooding as a results of river discharge or sea level rise. Very promising results are obtained in the simulation under uncertainty for different discount rates and learning process about the actual development of climate change. direct links exist with Haaglanden and Deltacommisariaat.

WP7, although behind schedule is one of the first projects that looks into appropriate indicators for adaptation to climate change and in the contacts with the stakeholders from Haaglanden this already has been identified as an urgently needed domain of research.

Prospects

In the coming years we envisage to complete the research projects as scheduled. This will results in a very active contribution to the preparation and planning of adaptation in the Netherlands and in a major contribution of the scientific methods in this domain, as sketched in the report.

We do not see any major bottlenecks for the progress of the research. In general we would be in favour of a reduction of the bureaucratic burden of participation in such a large programme. The reporting, auditing and reviewing procedures tend to be excessive and go at the expense of research progress.

What is the value added of the consortium?

The value added of the consortium is that it provides a fundamental scientific analysis of how adaptation measures can contribute to the reduction of climate change impacts by a careful design of regional adaptation strategies. We develop scenarios to illustrate what would happen without adaptation, we make an inventory of adaptation options and we analyze what would be good adaptation strategies in terms of cost, benefit and optimal timing. We do not only develop new scientific methods and insights, but also communicate with stakeholders and policy makers.

How are the results disseminated?

The results will be communicated in a large variety of workshops, conferences, meetings and in interaction with stakeholders and policy makers, not only at the local level, but also at the regional level (Haaglanden, Rotterdam area) and the national and international level (international conferences, integration in EU programmes, and through international publications). Results will be reported in popular articles, articles for a professional audience, peer reviewed journal articles and book chapters. We are also producing a newsletter.(see Annex 5 Publications)

Annex 1. Facts and Figures

FACTS AND FIGURES

Consortium T8 – Tools for adaptation strategies

Theme 8	Tools for adaptation strategies			
Title (short)	Tools for adaptation strategies			
Duration	1 January 2010 – 31 December 2014			
Consortium leader	Prof. Dr. E.C. van Ierland Environmental Economics and Natural Resource Group Wageningen University			
Financial officer	S. (Sylvia) Meewis (WUR)			
Communication officer	W.G.J.(Wil) den Hartog-van Rooijen (WUR, Maatschappijwetenschappen)			
Project coordinator KfC	Kim van Nieuwaal			
Consortium partners	∇ Wageningen University ∇ Alterra-WUR Wageningen ∇ Vrije Universiteit Amsterdam ∇ TNO Delft ∇ Deltares Utrecht ∇ The Netherlands Environmental Assessment Agency (PBL) Den Haag ∇ TU Delft ∇ IIASA Laxenburg ∇ Potsdam Institute for Kima Forschung ∇ JRC ∇ Department of primary industries State of Victoria ∇ Reg. Env. Center for Central and Eastern Europe REC ∇ University of British Columbia ∇ RWTH Aachen			
Website	http://knowledgeforclimate.climateresearchnetherlands.nl/decisionsupporttools			
Finance	**Initial**[1]		**Actual prognosis**	
	Minimal total budget	€ 3.950.000	Total budget[2]	€ 4.891.000
	Maximum KfC subsidy	€ 2.600.000	KfC subsidy[2]	€ 2.600.000
	Minimum matching	€ 1.350.000	Matching knowledge institutes (own contribution)	€
			External matching[3]	€
Steering board	∇ Peter Nijkamp (chairman)			

	▽ Marten van der Gaag (vice chairman) ▽ Eke Joustra (I&M) ▽ Kees Miedema (HSHL) ▽ Harold van Waveren (HSGR) ▽ Henk Scholten (Geodan) ▽ Carl Koopmans (SEO)

Structure of the theme

Theme 8						
Work package 8.1	Work package 8.2	Work package 8.3	Work package 8.4	Work package 8.5	Work package 8.6	Work package 8.7
8.1.1	8.2.1	8.3.1	8.4.1	8.5.1	8.6.1	8.7.1
8.1.2			8.4.2			
			8.4.3			

Organization of the work packages

Work package 8.1	**Integrating and downscaling national socio-economic scenarios**
Wp leader	Dr. Eric Koomen (VU, FEWEB) Prof. Dr. Piet Rietveld (VU, FEWEB)
Duration	4 years, July 2010 – December 2013
Project 8.1.1	Integrating sector-specific models in a land-use modeling framework
Project leader	Prof.dr. Piet Rietveld / Dr Eric Koomen
Duration	3 years, July 2010 – July 2013
Other project members	Dr. Eric Koomen (researcher) Dr. Peter Verburg (researcher) Dr Jasper Dekkers (Postdoc)
Project 8.1.2	Incorporating intensity and multiple functionality in the land-use model
Project leader	Prof. dr. Piet Rietveld Dr. ir. Peter Verburg
Duration	4 years, July 2010 – December 2013
Other project members	Derek van Berkel (PhD candidate VU, FALW/IVM) Chris Jacobs (PhD candidate VU IVM)

Work package 8.2	Assessing the economic impacts of flood risks
Wp leader	Prof. Dr. M.W. Hofkes (VU, IVM) In cooperation with: dr. O Ivanova (TNO) Dr. N.M. Pieterse (PBL)
Duration	4 years, February 2010 – December 2013
Project 8.2.1	Development of methodological framework for integration of Computable General Equilibrium and multi-agent modeling approaches for flood risks
Project leader	Prof. dr. M.W. Hofkes
Duration	48 months, February 2010 – December 2013
Other project members	Prof. dr. P. Rietveld (researcher) Dr. O. Ivanova (postdoc) Dr. N. Pieterse (researcher) H. Groot (postdoc) Dr. J. van Minnen (researcher) Dr. L. de Bree (researcher) B. Rijken (postdoc) O. Kuik (researcher) T. Filatova (postdoc) T. Husby (PhD candidate IVM-VU)

Workpackage 8.3	Interactive development of spatial adaptation strategies
Wp leader	Dr. Ron Janssen (IVM-VU, FALQ)
Duration	4 years, June 2010 – December 2014
Project 8.3.1	Interactive development of spatial adaptation strategies
Project leader	Dr. Ron Janssen
Duration	4 years, June 2010 – December 2014
Other project members	Prof.dr. Henk Scholten, FEWEB, VU (promotor) Prof dr J.Aerts, IVM, VU (promotor) Drs T. Eikelboom (promovendus)

Workpackage 8.4	Visualization and simulation of impacts and strategies
Wp leader	Dr. H. Goosen (Alterra) Dr. G. de Haan (TU Delft)
Duration	48 months, January 2010 – December 2013
Project 8.4.1	Development, application and testing visualizations for knowledge transfer in adaptation planning
Project leader	Dr. Hasse Goosen (researcher) Prof. dr. ir. A. Bregt (researcher)

Duration	48 months, January 2010 – December 2013
Other project members	--
Project 8.4.2	Simulating flows and flood flows in rural and urban areas
Project leader	Prof. dr. ir. G.S. Stelling (researcher)
Duration	48 months, January 2010 – December 2013
Other project members	--
Project 8.4.3	Interactive simulation and 3D visualization for water protection policy development
Project leader	Dr.ir. Gerwin de Haan (researcher)
Duration	36 months, August 2010 – Juli 2013
Other project members	M. de Groot (PhD candidate) C. Kehl (PhD candidate)

Workpackage 8.5	**Economic modeling and assessment of the impacts of climate change and adaptation strategies on freshwater resources**
Wp leader	Prof. dr. R. Brouwer (IVM-VU, FALW)
Duration	4 years, January 2010 – December 2013
Project 8.5.1	Economic modeling and assessment of the impacts of climate change and adaptation strategies on freshwater resources
Project leader	Prof. dr. R. Brouwer In collaboration with: J.Kind (Deltares)
Duration	4 years, January 2010 – December 2013
Other project members	Dr. A. Jeuken (researcher) Ir R. van Duinen (junior researcher) Dr J. Kind (researcher) J. Levin-Koopman (PhD candidate)

Workpackage 8.6	**Optimal timing, cost benefit analysis and adaptation strategies**
Wp leader	Prof. dr. E.C. van Ierland (WUR) In close cooperation with: dr. H-P Weikard (WUR)
Duration	4 years, January 2010 – December 2013
Project 8.6.1	Optimal timing, cost benefit analysis and adaptation strategies
Project leader	Prof. Dr. E.C. van Ierland Dr. Hans Peter Weikard
Duration	4 years, January 2010 – December 2013
Other project	T. van der Pol, MSc (PhD candidate)

members	

Workpackage 8.7	Monitoring and evaluation of climate change impacts, vulnerability and adaptation policies at different spatial scales
Wp leader	Dr J. Klostermann
Duration	4 years, April 2010 – February 2014
Project 8.7.1	Monitoring and evaluation of climate change impacts, vulnerability and adaptation policies at different spatial scales
Project leader	Dr J. Klostermann (researcher)
Duration	4 years, April 2010 – February 2014
Other project members	Ir K. van de Sandt (researcher)

	Theme 8 – per work package							
	1	2	3	4	5	6	7	Tot.
PhD	2	1	1	2	1	1		8
postdoc	1	4						5
researcher	3	5	1	4	3	2	2	20
Other			2					2

PhD candidates/promovendi

name	University	project code
Derek van Berkel Chris Jacobs	VU University, FALW/IVM VU University, FEWEB	8.2.1
Trond Husby	IVM VU	8.2.1
Drs T. Eikelboom	VU University IVM	8.3.1
Christian Kehl Monique de Groot	TU Delft DHV	8.4.1
Jason Levin-Koopman	IVM VU	8.5.1
Thomas van der Pol	Wageningen University	8.6.1

postdocs

name	University	project code
Dr. Eric Koomen	VU University, FEWEB-RE	8.1.1
Dr. Jasper Dekkers	VU University, FEWEB-RE	8.1.1
dr.ir. Gerwin de Haan	TU Delft, Faculty EEMCS	8.4.3

researchers

name	University	project code
Prof. dr. P. Rietveld	VU FEWEB	WP 8.1; 8.1.1; 8.1.2; 8.2.1
Dr. O. Ivanova	TNO	8.2.1
Dr. N. Pieterse	PBL	WP 8.2; 8.2.1
Dr. Hasse Goosen	WUR	8.3.1; WP 8.4; 8.4.1
Prof. dr. ir. A. Bregt	WUR	8.4.1
Prof. dr. ir. P. Vellinga	WUR	8.4.1
Prof. dr. Ir. G.S. Stelling	TU Delft CEG	WP 8.4; 8.4.2
Dr. R. van Lammeren	WUR	8.4.1
Dr.ir. Gerwin de Haan	TU Delft	8.4.3
Dr. ir. Peter Verburg	WUR	WP 8.1; 8.1.2
Prof. dr. M.W. Hofkes	VU IVM	WP 8.2; 8.2.1
Dr. Ron Janssen	VU IVM FALQ	WP 8.3; 8.3.1; 8.4.1
Prof. dr. R. Brouwer	VU IVM FALW	WP 8.5; 8.5.1
Prof. dr. E.C. van Ierland	WUR	WP 8.6; 8.6.1
Dr. Hans Peter Weikard	WUR	8.6.1
Dr. ir. Rob Swart	Alterra	WP 8.7; 8.7.1

other

name	Affiliation	project code
Prof.dr. Henk Scholten, (promotor)	VU FEWEB	8.3.1
Prof dr J.Aerts (promotor)	VU IVM	8.3.1

PPO (project publication officers)

name	Affiliation	work package / project code
Mrs. Wil den Hartog	Wageningen University	8.6

Matching projects (cofinancieringsprojecten)*
1. MEDIATION - Methodology for Effective Decision-making on Impacts and AdaptaTION - EU FP7 (PBL)
Adjacent projects (aanpalende projecten)

1. CcSP-LANDS project (KvR)
2. EC-JRC and EC-DG - Environment to develop a European land-use model (PBL)
3. LUMOS-development project (Netherlands Environmental Assessment Agency)
4. Roadmap to a climate proof Netherlands. (PBL)
5. EU development of system of regional models (TNO)
6. Water board Delfland CBA and insurance alternatives Woudse Polder (TNO)
7. Deltares National water safety alternatives 21st century (TNO)
8. ME6 “Spatial decision support for management of Dutch fen meadows” (KvR)
9. Waarheen met het Veen (LmW)
10. KNOWSEAS: Knowledge-based sustainable management for Europe"s Seas (...)
11. NAS tools
12. 3Di water management project (TU Delft,, Deltares, and Nelen & Schuurmans)
13. EU project SIRRIMED (...)
14. BSIK IC5 (KvR project)
15. Deltaprogramme
16. Climate Adaptation Modelling water scenarios and sectoral impacts (EU DG ENV)

**Cofinancieringsprojecten dienen goedgekeurd te worden voordat ze opgenomen kunnen worden als cofinanciering. Alleen goedgekeurde cofinancieringsprojecten komen in dit overzicht te staan.*

Key publications of the consortium (max. 5). For complete list check the website
G. de Haan, Scalable visualization of massive point clouds, in Management of massive point cloud data: wet and dry, P.J.M. van Oosterom, M.G. Vosselman, Th.A.G.P. van Dijk, M. Uitentuis (Editors), Nederlandse Commissie voor Geodesie 49, Delft, September 2010, pp 59—67 (ISBN: 978 90 6132 322 8)
Bruin, K.C. de, Weikard, H.P. and Dellink R. (2011). The role of proactive adaptation in international climate change mitigation agreements, CERE Working Paper, Vol. 9.
Weikard, H.P., Dellink, R. and Ierland, E.C. van (2010). Renegotiations in the Greenhouse, Environ. Resource Econ., 45: 573-596.
Berkel, D.B. van and Verburg, P.H. (2012). Combining exploratory scenarios and participatory backcasting: using an agent-based model in participatory policy design for a multi-functional landscape. Landscape Ecol. 27: 641-658
Nagashima, M., Weikard, H.P., Bruin, K. de and Dellink, R. (2011). International climate agreements under induced technological change, Metroeconomica, 62:4, p. 612-634.

Annex 2. Summary research proposal and work package descriptions

See attachment or download:
http://promise.klimaatvoorruimte.nl/pro1/publications/show_publication.asp?documentid=7111&GUID=9ae86037-c97e-4420-b3bd-0700acaa2fe9

Annex 3. Research parties involved

Contributing knowledge institute (name, address)	Research group and leading researcher
1 Wageningen University, Hollandseweg 1 6706 KN Wageningen	Environmental Economics and Natural Resources Leading researcher Prof. Dr. E. (Ekko) C. van Ierland Geo-information Science and Remote sensing Leading researcher Prof. Dr. Ir. (Arnold) K. Bregt
2 Alterra-WUR Droevendaalsesteeg 4 6708 PB Wageningen	Center for Water and Climate, Earth systems science and climate change group Leading Researcher Dr. Ir J. Klostermann and Dr. H. (Hasse) Goosen Centre for Geo-Information Leading Researcher Ir. J.J.F. (Jan-Erik) Wien
3 Vrije Universiteit, De Boelelaan 1105 1081 HV Amsterdam	Institute for Environmental Studies Leading researchers Prof . Dr. M. (Marjan) W. Hofkes Prof. Dr. R. (Roy) Brouwer Dr. R. (Ron) Janssen Department of Spatial Economics Prof. Dr. P. (Piet) Rietveld
4 TNO Innovation and Environment Postbus 49 2600 AA Delft	TNO Innovation and Environment Leading researcher Dr. O. (Olga) Ivanova
5 Deltares PO Box 85467 3508 AL Utrecht	Deltares Leading researcher Dr. A. (Ad) Jeuken
6 The Netherlands Environmental Assessment Agency (PBL) Oranjebuitensingel 6 2511 VE Den Haag	Netherlands Environmental Assessment Agency (PBL) Leading researcher Dr. N. (Nico) Pieterse
7 TU Delft, Faculty of Civil Engineering and Geosciences, Stevinweg 1, 2628 CN Delft TU Delft, Faculty of Electrical Engineering, Mathematics and Computer Science Mekelweg 4, 2628 CD Delft TUDelft	Faculty of Civil Engineering and Geosciences, Section of Fluid Mechanics, Faculty of Electrical Engineering, Mathematics and Computer Science, Section Computer Graphics Leading Researchers Prof. dr. ir. G (Guus).S. Stelling Dr. ir G. de Haan

foreign research partner(s)* (name, address)	Research group and leading researcher
1. IIASA, Laxenburg, Austria 2. Potsdam Institute for Klima Forschung, Postdam,Germany 3. JRC 4. Department of primary industries, State of Victoria, Australia 5. Reg. Env. Center for Central and Eastern Europe REC 6. University of British Columbia – Collaborative for Advanced Landscape Planning, Canada 7. RWTH Aachen, Center for Computing and Communication	1 IIASA Laxenburg, Austria Leading researcher Dr. Reinhard Mechler 2 PIK, Potsdam, Germany, Leading Researcher Dr. Juergen Kropp 3 JRC Leading Researcher Dr. Carlo Lavalle 4. Department of primary industries Leading researcher Dr. Christopher Pettit 5. REC Leading Researcher Dr. Marta Bonifert 6. Local Climate Change Visioning Tools and Processes for Community Decision-Making Leading Researcher Dr. David Flanders; Prof. Stephen Sheppard 7. RWTH Leading Researcher Prof. dr. Torsten Kuhlen

Annex 4. Hotspots and stakeholders

Hotspot Haaglanden			
Stakeholder organisations involved	Case study	Co financing	In kind
- Haaglanden	Haaglanden	200 k€	- Inzet - Ca 3 pers
- Waterboard Delfland	Case Delfland inundation	0 k€	- 1 pers

Annex 5. Publications

Type	Year	Reference	Download
Book (intranet)	2011	Schrojenstein Lantman, J., Verburg, P.H., Bregt, A. and Geertman, S. 2011. Core Principles and Concepts in Land-Use Modelling: A Literature Review. In: Koomen, E., Borsboom-van Beurden, J. (eds). Land-Use Modelling in Planning Practice. Springer, Netherlands, pp 35-37.	
Book (public site)	2011	Dekkers, J.E.C. and Rietveld, P. (2011). Explaining land-use transition in a segmented land market; potential input for Land Use Scanner, Chapter 9. In: Koomen, E., Borsboom-van Beurden, J. (eds). Land-use modelling in planning practice. GeoJournal Library Vol. 101, Springer, Dordrecht.	
Brochure (public site)	2010	Ierland, E.C. van (2010). Decision Support Tools. Flyer on theme 8, Knowledge for Climate.	
Popular Article about Science (public site)	2011	Overdijk, C. (2011) Randstad moet functies stapelen. Binnenlands Bestuur, 23 april 2011, p. 18.	
Presentation (public site)	2011	Dekkers, J.E.C. (2011). Grenzen aan stedelijke verdichting; Een kwantitatieve verkenning van verdichtingsopties in Haaglanden. PBL-Ruimteconferentie, 19 april 2011, Rotterdam.	
Presentation (public site)	2012	Rijken, B., Koomen, E. and Zondag, B. (2012). Residential land-use density simulation. Paper presented at the workshop on Complexity Modeling for Urban Structure and Dynamics, 15th AGILE International Conference on Geographic Information Science, April 24-27, 2012, Avignon, France.	
Presentation (public site)	2011	Dekkers, J.E.C., Koomen, E., Jacobs, C., Koekoek, A. and Rijken, B. (2011). Grenzen aan stedelijke verdichting; een kwantitatieve verkenning van verdichtingsopties in Haaglanden. Abstract voor de PBL-Ruimteconferentie 2011, 19 april, Rotterdam.	
Project Factsheet (public site)	2010	Projectproposal Theme 8 Decision Support Tools (2010). Work Package 3.	
Project Factsheet (public site)	2010	Projectproposal Theme 8 Decision Support Tools (2010). Work Package 6.	
Project Factsheet (public site)	2010	Projectproposal Thema 8 Decision Support Tools (2010). Work Package 1.	
Project Factsheet (public site)	2010	Projectproposal Theme 8 Decision Support Tools (2010). Work Package 4.	
Project Factsheet (public site)	2010	Projectproposal Theme 8 Decision Support Tools (2010). Work Package 5.	
Project Factsheet (public site)	2010	Projectproposal Theme 8 Decision Support Tools (2010). Scientific aspects.	
Project Factsheet (public site)	2010	Projectproposal Theme 8 Decision Support Tools (2010). Societal aspects.	
Project Factsheet (public site)	2010	Projectproposal Theme 8 Decision Support Tools (2010). Summary.	
Project Factsheet (public site)	2010	Projectproposal Theme 8 Decision Support Tools (2010). Work Package 2.	
Project Factsheet (public site)	2010	Projectproposal Theme 8 Decision Support Tools (2010). Work Package 7.	

Project Newsletter (public site)	2012	Thema 8 Newsletter Decision Support Tools (2012). Issue 3, May 2012.	
Project Newsletter (public site)	2011	Thema 8 Newsletter Decision support tools (2011). Number 2, October 2011.	
Project Newsletter (public site)	2011	Thema 8 Newsletter Decision support tools (2011). Number 1, March 2011.	
Report (public site)	2011	Bruin, K.C. de, Weikard, H.P. and Dellink R. (2011). The role of proactive adaptation in international climate change mitigation agreements, CERE Working Paper, Vol. 9.	
Report (public site)	2011	Walda, H. (2011). De invloed van ruimtelijke factoren op krimpregio's. BSc thesis, VU University, Amsterdam.	
Report (public site)	2011	Jacobs, C.G.W. (2011). De drijvende kracht van mobiliteit. Spinlab Research Memorandum SL-09, 51 pages.	
Report (public site)	2011	Jacobs, C.G.W. (2011). Integrating spatially explicit potential accessibility measures in Land Use Scanner. Spinlab Research Memorandum SL-10, 30 pages.	
Scientific Paper (public site)	2010	Weikard, H.P., Dellink, R. and Ierland, E.C. van (2010). Renegotiations in the Greenhouse, Environ. Resource Econ., 45: 573-596.	
Scientific Paper (public site)	2011	Weikard, H.P. (2011). Towards a global climate constitution. Published in: Held, M. et al. (eds. 2011) Institutionen okologischer nachhaltigkeit. Normative und institutionelle Grundfragen der Okonomik, Jahrbuch 9. Marburg: Metropolis. Pp 89-106.	
Scientific Paper (public site)	2011	Wangler, L., Altamirano-Cabera, J.C. and Weikard, H.P. (2011). The political economy of international environmental agreements: a survey. Jena Economic Research papers, Vol. 038.	
Scientific Paper (public site)	2011	Overdijk, C. (2011). Randstad moet functies stapelen, Binnenlands Bestuur, 23 april 2011, p. 18.	
Scientific Paper (public site)	2010	Weikard, H.P. and Dellink, R. (2010). Sticks and carrots for the design of international climate agreements with renegotiations, Ann Oper Res DOI 10.1007/s10479-010-0795-x.	
Scientific paper peer reviewed (public site)	2011	Nagashima, M., Weikard, H.P., Bruin, K. de and Dellink, R. (2011). International climate agreements under induced technological change, Metroeconomica, 62:4, p. 612-634.	
Scientific paper peer reviewed (public site)	2012	Berkel, D.B. van and Verburg, P.H. (2012). Combining exploratory scenarios and participatory backcasting: using an agent-based model in participatory policy design for a multi-functional landscape. Landscape Ecol. 27: 641-658.	
Manuscript	2012	Goosen, H., M.A.M. de Groot-Reichwein et al. (2012) A tool for climate adaptation services in spatial planning. Regional Environmental Change (submitted)	
Manuscript	2012	Groot-Reichwein, M.A.M. de, H. Goosen et al. (2012) How can climate adaptation be incorporated in spatial planning at the local scale: a guiding principle approach for the Zuidplaspolder. Regional Environmental Change (submitted)	
Manuscript	2012	Groot-Reichwein, M.A.M. de, H. Goosen et al. (2012) Design principles for adaptation planning. 19th ialeUK conference, Landscape ecology: linking environment and society (in prep)	
Manuscript	2011	Christian Kehl, Gerwin de Haan “Visualization on a Budget for Massive LIDAR Point Clouds”, Berend Wouda, Msc Thesis Computer Science, August 2011	

		(see http://repository.tudelft.nl/view/ir/uuid:ffa05e28-68dc-4d5a-af66-5d00530bf1e8/) "Interactive Simulation & Visualization of Flooding Scenarios", , Accepted poster at International Supercomputing Conference, Jun 17-21 2012, Hamburg, Germany,	
Manuscript	2012	"Subgrid flooding: making high resolution available", A. van Dam, O. Kleptsova (Deltares, Delft, The Netherlands), G.S. Stelling (Delft University of Technology, Delft, The Netherlands), O. Pleumeekers (Nelen & Schuurmans, Utrecht, The Netherlands), Submitted to FloodRisk 2012 (Rotterdam)	
Manuscript		"Quadtree flooding simulations with sub-grid Digital Elevation Models.", G.S. Stelling (Delft University of Technology, Delft, The Netherlands), Submitted to Flood Modelling, Water Management themed issue. (see http://www.elabs10.com/c.html?rtr=on&s=x8pb27,mqek,a0e,48lv,5h88,6785,cdcu)	
Publication	2010	“Scalable visualization of massive point clouds”, G. de Haan, in Management of massive point cloud data: wet and dry, P.J.M. van Oosterom, M.G. Vosselman, Th.A.G.P. van Dijk, M. Uitentuis (Editors), Nederlandse Commissie voor Geodesie 49, Delft, September 2010, pp 59—67 (ISBN: 978 90 6132 322 8) http://www.ncg.knaw.nl/Publicaties/Groen/49VanOosteromPointClouds.html	
Popular article	2010	"Overtsromingsmodellen met hoge resolutie", H2O nr21/2010	
Popular article	2011	"Informatiestrategie in stedelijk water",Riolering Maart 2011	
Popular article	2011	"Watermanagement is informatiemanagement", H2O nr9/2011	
Popular article	2011	"3Di water management: more insight, lower costs", VIEWS no5/2011	
Popular article	2011	"De 3Di professor", Waterproof Nov.2011	
Popular article	2011	"3Di maakt het onvoorstelbare zichtbaar", Waterproof Nov. 2011	
Presentation	2012	Gerwin de Haan, Wytze Schuurmans, Elgard van Leeuwen, 16-10-2012, “3Di waterbeheer”, Eindconferentie Waterkader Haaglanden, Den Haag.	
Presentation	2012	Gerwin de Haan, 8-12-2012, “3Di voor klimaatadaptatie”, Kennis voor Klimaat Workshop, Delft. (vele gerelateerde 3Di presentaties in zusterproject)	
Manuscript	2012	Thomas van der Pol, Ekko van Ierland, Hans-Peter Weikard (2012) Efficient dike height revisited: cost minimisation under an unknown rate of the water level increase and with the possible arrival of new information, draft version (to be submitted)	
Presentation	2012	Thomas van der Pol, Ekko van Ierland, Hans-Peter Weikard, Kennisbijeenkomst Deltaprogramma (3 april 2012), parallelsessie adaptief deltamanagement “Investeren in een homogene dijk onder onzekerheid met leren over piekafvoeren” (in Dutch)	
Presentation	2011	Thomas van der Pol, Ekko van Ierland, Hans-Peter Weikard, Workshop 2 Regionale AdaptatieStrategie Haaglanden (8 december 2011), “Kosten en baten van adaptatiemaatregelen” (in Dutch)	
Manuscript	2012	van de Sandt K., Klostermann J., van Minnen J., van Bree L., 2012, Climate adaptation monitoring and indicators, informal note, KvK	

Manuscript	2012	Jelle van Minnen, Mike Harley (AEA), Kaj van der Sandt, Willem Ligtvoet, 2012, Adaptation indicators in Prutsch, McCallum, Grothmann, Swart and Schauser (Eds) The Routledge Climate Change Adaptation Manual - Lessons learned from European and other industrialized countries, , in prep	
Workshop participation		Jelle van Minnen was invited to participate in a workshop on the monitoring of climate adaptation in the UK.. "The aim of this workshop is to bring together climate change impact and adaptation experts from different nations to share experiences and discuss approaches for assessing the impacts of climate change and developing adaptation responses. There will also be an opportunity share experiences on monitoring and evaluating progress on adaptation.	
Workshop participation		Kaj van de Sandt (replacing Jelle van Minnen) participated in a workshop organized by Sniffer UK about adaptation monitoring strategies in the UK. Different indicator frameworks were discussed with stakeholders and policy makers from England, Scotland, Whales and Northern Ireland.	