Scientific aspects

Content

1. Description of the research programme

1.1 Problem definition, aim and central research questions

Problem definition

The latest climate impact assessments show that climate change will cause an increasing mismatch between demand and supply of fresh water in many densely populated deltas around the world. This mismatch is a result of more frequent droughts, lower summer river discharges and increasing salinisation associated with changing atmospheric circulation, precipitation patterns and sea level rise. These trends not only influence the water supply but also the demand.

Recent studies for the Netherlands also show that the current water supply strategy is not climate proof in the long term. A future ‘climate proof’ fresh water supply therefore has become a national top priority on the Dutch water policy agenda.

Conventional strategies in the Netherlands rely on the intake of fresh surface water from the rivers Rhine and Meuse. This water is used to replenish regional surface water lost to irrigation, evaporation and infiltration to thegroundwater system. Large amounts of intake water are used to dilute surface waters and to mitigate the effects of saline groundwater seepage. These conventional strategies may not be robust, as river discharges become more erratic, salt water wedge from the sea intrudes further upstream rivers, water demand intensifies in drier growing seasons and saline groundwater seepage in low-lying areas with controlled water levels (and confronted with ongoing soil subsidence) increases. Also if current trends in the agricultural sector continue the demand for good quality water will increase further.

This affects many vital economic sectors, ranging from local to national level. The importance and urgency of this problem is underpinned by policy statements from the Delta Committee and the draft National Water Plan.

In the call for proposals the following main (hotspot) questions were identified:

a) How can fresh water supply be robustly designed in order to be flexible in anticipating a wide range of climate effects?
b) What opportunities are offered by reduction of water demand and/or water reuse?
c) What are opportunities and setbacks of water supply by allocation and buffering?
d) What opportunities are offered by water technology and spatial planning?
e) How can we adapt to periods of water scarcity and water quality changes?
f) How effective are these strategies on different scales?

These questions reveal a strong need for research on practical solutions and adaptation strategies.

Aim

The aim of the proposed research is to develop robust, flexible and long-term solutions from a local to regional perspective which can contribute to successful strategies to bridge the growing mismatch between demand and supply of fresh water (quantity and salinity) in the changing Dutch Delta.
We can not cover the whole of the Netherlands and the proposed research will also not lead to complete strategies. Therefore the ambition or scope is to contribute significantly at least to strategy development for the three hotspotarea's involved in conjunction with other research and policy oriented programs (see also 3A2).

Central research questions

1. Our main research questions are derived from the questions as described above and apply within the above mentioned scope of the program.
2. What range of conditions should be taken into account to assess the severeness of an inadequate fresh water supply (evaporation, precipitation, river discharges, sea level rise and related salt water intrusion, international economic changes)
3. How will fresh-water availability within the coupled groundwater-surface water system change due to climate change and how can the self-reliance of water users be increased?
4. To what extent can tolerance levels of different land uses be stretched? What opportunities for the reduction of the fresh water demand are possible?
5. What is the potential of water technology for providing solutions for regional self-sufficiency in the fresh water supply?
6. What approach should be used to build robust and flexible adaptation strategies, given the uncertainties in the long-term prediction of future climate change effects, and of other relevant socio-economic developments?

How can knowledge about specific adaptation measures, perspectives of different stakeholders, available approaches for tackling uncertainty, be integrated to build strategies for selected pilot areas.

Further elaboration of the research questions according to workpackages can be found under 2B2 and in appendices 1 and 2.

1.2 Program outline and research approach

In the background document of the call for proposals the hotspot questions given above are further elaborated. The elaboration of the questions ask for quite complete and integrated (beta-gamma) analysis and solutions. In addition under the title of “service function” it is advised to seek cooperation with cross-cutting themes as Governance, decision-support tools and climate projections. The main questions are derived from a series of more specific, sometimes very localized hotspot questions. In this proposal we cannot cover all these angles simultaneously: being comprehensive, scientifically profound and tailored to the needs of all the hotspots

Therefore, we choose to focus on in-depth scientific research on promising local and regional solutions with impact on the national fresh water budget. The emphasis is on the agriculture and water supply sectors as well as nature. With this focus of ‘solutions at the source’ we connect best with the questions asked by the hotspots. Through upscaling we can contribute to national policy oriented programs. In the period between pre-proposal and the writing of the full proposal the research questions have become more specific but there has been no reason for a different orientation or set up of the programme.

The Delta Programme, the elaboration of the national water plan with fresh water supply as a main theme, will be the main policy oriented programme in the forthcoming years. The research in our proposal will hence be carried out as much as possible in the context of this Delta Programme and will use the data and tools from their research, but will not address completely the national key issues involved in that programme directly. At the other hand it is expected that the outcomes of this KfC research programme will in turn be complementary to the national Delta programme.

Several disciplines will be combined in integrating cases. The work will be organized into research projects where involved stakeholders from the hotspots, PhD students, Postdocs and experts from research institutes will closely work together. Hence, the programme will not only have a high scientific and innovative profile, but will also result in practical solutions.

Break down of the programme

The programme is built around the research questions given above, which are directly addressed in 6 Work Packages (see figure below):

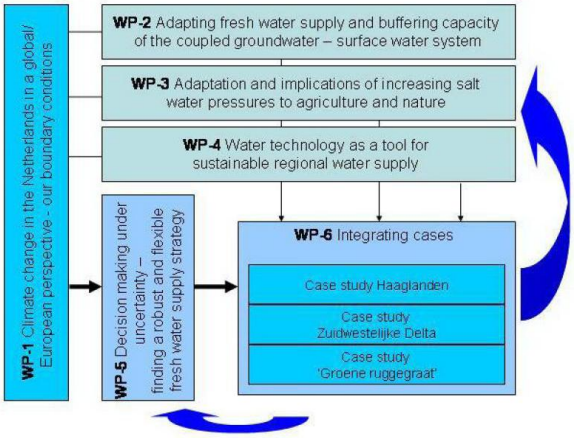

Figure 3.1 Outline of the programme.

In WP-2 to WP-4 the potential of different regional to local adaptation measures is investigated (WP-6). To be able to do this in the right current and future context, boundary conditions for climate, watermanagement and economics are elaborated in WP1. These boundary conditions will be associated with all sorts of uncertainties. In WP5 methodology and specific guidelines for decision making under these uncertainties in drought and salinisation risks are object of study. Finally in WP6, input from all other WP's e.g. potential of specific measures, specific boundary scenario's and guidelines will be used to build and test adaptation strategies for the case study areas. WP-2 till WP-4 have a strong beta-orientation and are oriented at the core of this theme. WP-1, WP-5 and WP-6 include major gamma-components and have linkages with other themes, in particular theme 6, 7 and 8. All WP's contribute to the pilots in WP6, but the pilots are at the same time also testcases for the measures or aproaches developed in the other WP's as indicated by the blue arrows in figure 3.1. Each WP has a particular study case (ranging from field experiments to inquiries) in one or more pilot areas. In this way knowledge and its applicattion is iteratively developed.

Main deliverables, outcome of the programme

The main outcome of the programme is expected to be that at the end there will be good insight in the potential of the investigated adaptation measures both for the regional cases and, through upscaling, national policy on a climate proof water supply and demand. For Hotspot parties a direct contribution to their regional adaptation strategies is made. So the main integration in this programme will be on the level of regional pilots. In cooperation with the Deltaprogramme we will try to put these regional solutions in perspective of national solutions (upscaling). Such an effort for synthesis will be made at the start of the programme as well as to the end. In addition it is expected that there will be better understanding of what the most critical boundary conditions (e.g. return periods of droughts, low river discharges, tolerance levels, economic setting) are and how with the uncertainties involved robust policy making is possible. Both aspects will be a valuable input to the national Delta programme.

1.3 Innovative aspects and scientific output

Integrated multiple scale approach

With this programme we aim at broadening scientific knowledge and creating innovative solutions to contribute to more robust and flexible strategies to balance fresh water supply and demand in a changing climate. The innovative aspects on a general level are that we step down from the traditional top down national approach of guaranteeing the current service level by supply from the main water system and that we focus on bottom up local and regional measures. Given the complex nature of the fresh water supply problem – e.g. high pressure on water resources, complex organization of the water system, uncertainties about future conditions – simple solutions are not available and an integrated approach should be applied instead. A coherent academic research programme that addresses all aspects of this problem specific for the Netherlands conditions, including adaptation strategies, has not been carried out yet. Different from most studies is that we look to the possible response of water management to climate change within the whole river basin and associated water availability for the Netherlands and that we consider the relative economic position of the agricultural sector in an international changing context.

Salinisation, drought and storage of fresh water

Up to now studies of the processes behind the dynamics and future behaviour of the fresh groundwater storage and the salinisation from groundwater to surface water are limited. Even fewer studies exist of the effects of measures (e.g. innovative drainage systems) to counteract negative consequences. (Preliminary) results of field monitoring and modelling studies suggest that local and regional solutions – buffering and dynamic control of the fresh water storage – could be feasible. It is, however, unknown which solution is most effective in which situation, to what extent and how these measures could be up-scaled to large areas. In this programme, all these aspects will be addressed.

Adaptation of nature and agriculture

There has been substantial research on salt- and drought tolerance levels of plant species. Some recent scenario studies have looked at potential impacts of climate change. The main scientific progress that will be made in this programme is that the tolerance will be better assessed taken into account a much more realistic variation of boundary conditions in time using multiple year long time series.

Water technology as a tool for sustainable regional water supply

In the Netherlands, there is little experience with water technologies to store surface water in aquifers for later use by ASR, to desalinate brackish groundwater (e.g. by reverse osmosis or Memstil) and to dispose of the membrane concentrate by deep well injection. Yet these techniques could become an option where fresh groundwater is becoming scarce due to both ongoing salinisation and increasing demands of high quality water for agriculture, industry and drinking water supply. In addition, various polluted waters (like sewage effluent, drain water from glasshouses and rain water) may become an alternative water source, when treated with modern techniques that outcompete traditional expensive systems that require too much space or energy. However, implementation of these techniques is currently hampered by lack of knowledge on (i) their performance under Dutch hydrogeochemical conditions and (ii) their heavily counting environmental impacts (especially the brine issue). Research is

therefore needed to fill up these knowledge gaps, and to adapt and improve the techniques mentioned, in order to substantially contribute to local or regional fresh water supply.

Decision making and dealing with uncertainty

Compared to water safety issues little research has so far been carried out on decision making about drought and salinisation issues. Safety and drought are clearly different issues. Most focus in the Netherlands is on preventing an event (viz. the flood). Drought and salinisation issues on the other hand address a more continuous range of conditions and a more complex set of interests. In addition, a wide set of variables may change in the long term (such as soil use patterns, developments in agriculture, etc.), requiring consideration of a broader set of uncertainties some of which may not easily be quantified (so-called deep uncertainties). Moreover, while traditional approaches to dealing with uncertainties have a primarily defensive character (how to prevent unwanted outcomes at acceptable costs), a more open approach will be followed in this programme, exploring opportunities that future developments may bring, and considering the application of (real) options in light of these.

1.4 Relevance of the research programme in an international context

The attention of the scientific world on the impacts of climate change on drought and fresh water supply (and the linked salinisation) has grown in recent years. This is not only due to events (such as the drought of 2003 in Europe) but also due to the realization that droughts and salinisation are strongly related to food security. The researchers involved in this theme are already participating in several international research programmes in this field. The proposed research is supporting these researchers in further developing their science and their positions in the international science community. Although the main focus of the theme is on the drought and fresh water supply issues as existing in the Netherlands, in general the science and methodology involved is applicable in other parts of the world, in particular deltas. To give a few examples:

- Both the hydrological and economic situation around us will determine how hard we as the Netherlands will be hit when drought strikes or what kind of opportunities will emerge. The research on boundary conditions will be carried out in cooperation with European partners, in particular those involved in the Rhine and Meuse basins. This will give valuable insights for all parties.
- The KfC research will devlop strong ties with the Delta Alliance, a netwerk of Deltas with often similar problems (Francisco Bay, Vietnam, Indonesia and the Netherlands). Topics, like salinisation, drought and solt tolerance of crops, water technology, policy making under uncertainty will be applicable and can be shared within the network.
- Recognizing deep uncertainties and explicitly and methodically dealing with them in long-term planning andpolicy making is a relatively recently developed research field meeting with increasing international interest. The proposed work in WP-5 will help to strengthen the leading position of the Netherlands, in particular with respect to fresh water supply. We know of only one earlier application of a broad uncertainty analysis approach to a water supply problem world-wide, so there is much to be added and developed.

1.5 International cooperation

In preparing this proposal contacts have been made with international experts and institutes whose specific scientific knowledge is expected to benefit the quality of the proposed research. Their input will either be by involving them in the projects as actual research partner or by asking them to provide an advising or supervising role in a project, a Work Package or the full programme. For the full programme a Scientific Advisory Board will be established who willmeet twice to discuss the approach and progress of the projects. The following cooperation is foreseen:

Partners that will actually be involved in the project as **research partners**:

- Bundesanstalt für Gewässerkunde (dr. Thomas Maurer) - Germany, prominent partner of the KLIWAS project and the key applied research institute in this field in Germany, in particular for project 1.2
- British Geological Survey (Dr. Richard Ogilvy) – United Kingdom. Dr. Ogilvy´s role is to advice and supervise research in the field of applied geophysics for near-surface environmental, engineering and hydrogeological problems, for projects 2.1 and 2.2, among others for implementing an automated system for the long-term monitoring of vulnerable coastal aquifers and surface water systems. He is the developer of the Automated time-Lapse Electrical Resistivity Tomography (ALERT) system with EU FP6 funding (GOCE-CT-2004-505329). The ALERT technology (viz. getting geo-electric property changes) will directly be related to hydrogeochemical processes in the water system, particularly to salinisation in coupled groundwater - surface water systems. Dr. Ogilvy will be involved in the work of WP-2.
- University of Bologna (prof. Marco Antonellini) – Italy. Marco's role is incorporate his ongoing research in groundwater - surface water interactions in the Po Delta with our research findings in our Dutch Delta, for WP-2.
- Dr. David Pyne – United States, world renowned expert on ASR, author of the only existing book on ASR applications, for project 8.
- EPFL (Ecole Polytechnique Federal Laussane), Hydrology and Water Resources (prof. Andrea Rinaldo), Transport phenomena in the hydrological, ecohydrology etc, providing guidance and inspiration to several PhD students involved in the theme, in particular of WP-1, WP-2 and WP-3.
- INGREF (Tunisia), Centre National de Recherche en Genie Rural, Eaux et Forets (dr. Fethi Bouksila). Will give access to conduct experiments in Tunisia on the tolerance of different crops to salt as experimental fields are available on a fresh-salt gradient through Tunisia, in particular relevant for projects 3.1 and 3.2.

Experts / top scientist for advice and supervision (**Science Advisory Board**)

- Dr. Christian Langevin, U.S. Geological Survey. Dr. Langevin is an expert of research on the interaction between groundwater - surface water systems. especially in the Florida Area, a low-lying area like to the Dutch Delta.

- Prof. Richard Harding, Head of the Climate Section at CEH Wallingford. This group researches into the improvement of the representation of the land surface hydrology in global models. Deputy Director of CLASSIC EO Centre of Excellence, Partner in more than 15 EU projects (FP3-FP6).
- Prof. Dr. Robert Lempert, senior scientist at RAND corporation, specialist on long-term policy analysis; risk and uncertainty management; strategy under uncertainty.

In addition there two international workshops will be held (see section 4C)

1.6 Most important references

We consider the following references in particular relevant as base documents for the theme on fresh water supply

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Netherlands : anexploratory investigation (in Dutch). Meta-studie Zuidwestelijke Delta, Kennis voor Klimaat, 82 p.

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2. Interdisciplinarity

The programme intends to result in a methodology towards a climate proof fresh water supply, through robust and flexible solutions. This requires an interdisciplinary approach, as a wide range of issues need to be looked at, and a number of stakeholders with very different agenda's need to be involved in the process.

The consortium therefore includes a number of renowned organizations, reflecting the importance of cross-Institute and inter-disciplinary collaboration for meeting the complex tasks set by the project, but thereby also using the resources more efficiently. By including universities, research institutes and the private sector the project is approached both in a fundamental and applied manner.

The involved research groups cover a wide range of disciplines. These disciplines include: Natural sciences (including physical processes, monitoring, modeling) and technology: WP-1 (partly) and WP-2, WP-3 (which includes socio-economic issues) and WP-4; Socio-economic and policy sciences: WP-1 (partly) and WP-5-6; Applied research (applying research into practical solutions): WP-6

The expertise of the research groups is complementary and broad enough to ensure that all disciplines are represented. Although research is the key focus, the project will eventually result in insights that help the stakeholders to develop a methodology towards a climate proof water management system. Evidently, by including a number of case studies, the outcome of the different work packages can be integrated. It must be stressed that the researchers from the different research projects will be actively involved in the case studies. These cases will enrich our own developed knowledge but also offers very relevant test cases to the other themes.

In addition tot the expertise available within the consortium, the cooperation will be actively sought with the crosscutting themes 6,7, 8 to have available knowledge on: latest regionalized insights in drought scenario's and social economic scenario's, on economic valuation of adaptation options and on the organization of stakeholder participation.

3. Coherence between and synthesis of outcomes from the individual work packages

In this section, we will explicitly point out the connections between the individual WPs.

The proposal can be grouped into three disciplines (see Figure 3.1 in Section 3A2), viz.

1. Natural sciences (including physical processes, monitoring, modeling) and technology: WP-1 (partly) and WP-2, WP-3 and WP-4,
2. Socio-economic and policy sciences: WP-1 (partly), WP-5 and WP-6,
3. Applied research (applying research into practical solutions): WP-6,

Activities within WP-6, The Integrating Cases, ensures the coherence of the different WPs spanning these disciplines. For these Integrated Cases, viz. Haaglanden, Coastal Fen Meadows and South-western Delta, input from the WP-1, WP-2, WP-3 and WP-4 is vital to a successful implementation of hotspot adaptation strategies.

Moreover, to be able to make the step from single measures to long term strategies, given the uncertainties involved, concepts and guidelines to design and implement robust and flexible strategies will be developed for the cases in WP-5. Activities within the more fundamental research of WP-2, WP-3 and WP-4, such as field measurements, water system analysis, modelling, interview surveys, are carried out by PhD students and Post-docs in the physical component of the three Cases, so that WP-6 can make direct use of their preliminary results. An important role for the WP coordinator of WP-6 (together with the overall consortium leader) is to link the Cases (addressing the specific questions and issues of the hotspots) with the various research activities carried out in the other WPs (see Section 6E ‘Management of the research programme’). Vice versa the coordinators of the “technical” WP’s 1-4 should ensure that the research carried out under their guidance is tuned to the needs of the cases as far as possible.

The consortium will organize scientific meetings for the whole consortium (including PhD students and Post-docs) atleast twice a year, where all projects will be presented to each other and thoroughly discussed by all team members.
For the PhD students in particular a summer school will be organized. Integration of the results of the WPs is also taking place during the discussions and knowledge exchanges at the (international) workshops (see Appendix 8 ‘Time planning’).

In addition, specific WPs have strong interrelations with each other. These relations are identified below:

- WP-1 and WP-5: results on the variety of possible future boundary conditions for the Netherlands (WP1) will be used in project 5.1 (‘Adaptation under uncertainty: resilience as a strategy for climate proofing fresh water’;
- WP-2 and WP-3: changes in the fresh water volumes in brackish-saline environments or the salinity of surface

- water (both projects of WP-2) are closely linked to increasing salt water pressures to agriculture and nature (WP-3), e.g. via the quantification of present and future salt damage to crops;
- WP-2 (project 2.2) and WP-4 (project 4.1) are both focused on medium sized fresh water lenses in sandy creeks in brackish-saline environments: WP-2 on the quantification of the effects of changing boundary conditions under different hydrogeological conditions, and WP-4 on the performance of storage techniques in terms of water quality, storage capacity and recovery efficiency;
- WP-4 and WP-6: technological options for increasing self sufficiency of water supply developed in WP-4 will be tested in WP-6;
- WP-5 and WP-6: the case-based more in-depth uncertainty analyses performed in WP-5 will directly feed intoWP-6.

The mutual cooperation between the researchers of the WPs will be encouraged and therefore specialists of eachconsortium partner will have a task in each WP, wherever deemed relevant. In addition 10% of all scientific input (PhD students and Post docs, equivalent to 285 k€) in WP-1 to WP-5 is directed to WP-6. Each PhD student will be active in two cases, and if applicable, they will jointly work on the same problem.

All the abovementioned actions will ensure that outcomes of one WP are directly available to other WPs and that adjustments to the research directions can be made in time to serve the overall goals of the programme and the stakeholders involved.

1. (Expected) cooperation and coherence with other research themes

At various research fields potentials for cooperation with other themes have been identified. Discussion with the other themes have in some cases resulted in concrete agreements on cooperation (and are included in this proposal), in other cases it is still to be worked out on how such cooperation will take place.

Concrete agreements on cooperation have been reached with:

- Theme 1 (Water safety): joint PhD research on robustness analysis methods. Each theme has included half a PhD where we jointly carry out the development of the conceptual framework. The framework will be applied on flooding (theme 1) and on drought (theme 2).
- Theme 3 (Rural areas): their PhD-project “The future groundwater recharge: evapotranspiration response of vegetation to climate change” will be carried out in close co-operation with our PhD projects 2.1, 2.2, 3.1 and 3.3. Within theme 3, maps of ecosystem functioning will be made which rely amongst others on data on the salinity of surface waters (project 2.2). This theme will also investigate the potential adaptation strategies of farmers, which are determined partly by

the availability of fresh water. Within the case 'Groene Ruggengraat' (project 6.1) interviews with farmers and NGO's as a basis for agent based modeling will be done jointly with theme 3.

- Theme 6 (Climate projections): very strong linkage between several projects of WP-3 of theme 6 and various projects of our theme. In particular the following cooperation agreements have been made:
  - their project 3.1 and our project 1.2 where theme 5 will take care of the climatology while we will take care of the water management aspects. The hydrology we will do jointly.
  - cooperation between the PhD in their project 3.4 (coupling of hydrological and land use models) and our project 2.2 (hydrological modelling of groundwater-surface water interaction)
  - their project 6.7 (uncertainties in adaptation) and our WP-5 (Decision making under uncertainty)
  - the use of our integrated cases in the research of their projects 3.2 (coupling of climate and agronomic models) and 3.3 (case coupling of climate and ecosystems models)
- Theme 7 (Governance): close cooperation between our WP-5 (Decision making under uncertainty) and their WP-4 (Dealing with controversies) and their WP-5 (normative principles: legitimacy effectiveness and resilience). Theme 7 will address the same issues of resilience, adaptive capacity, etc., but they address the governance or institutional system, while the uncertainty-oriented research in our theme 2 addresses the socio-ecological system and the policies applied to that system.

Less concrete but still promising are the cooperation potential with the following themes. Contacts have been established but the mode of cooperation still have to be worked out in detail.

- Theme 5 (Infrastructure). In this theme the effects of exposure of concrete structures to saline groundwater will be investigated in WP-2 (Climate proofness of physical infrastructure), which potentially links to the research on salinisation in our WP-2.
- Theme 6 (Climate projections). Besides above specific cooperation we anticipate that theme 6 will provide the meteorological (rainfall, evaporation, etc.) boundary conditions under climate change for our cases studies in WP-6.
- Theme 8 (Tools) addresses decision making under uncertainty from a primarily economic, social costbenefit analysis; they will also elaborate economic approaches to investment decisions under (long-term) uncertainty which has strong ties with our WP-1 and WP-5.

Another form of synergy will be generated by cooperation on the three cases of our WP-6. The following cooperation possibilities are identified and partly already agreed upon with the other themes:

- Theme 3 (Rural areas) in particular in our integrated cases 'Groene Ruggengraat' and 'Zuidwestelijke Delta'.
- Theme 5 (Climate projections), in their WP-3, in particular in our integrated case 'Groene Ruggengraat'

- Theme 7 (Governance) in our integrated cases 'Haaglanden' (project 2.2: Realizing climate robust multifunctional land use through system synchronization) and 'Zuidwestelijke Delta' (project 2.3: The multilevel governance of climate adaptation)

2. Connection to finalized and current projects in KfC and other research programmes

Given the wide scope of this proposal there are many connections with KfC and other research programs. Below we highlight only a few, categorized by work package.

- **WP-1:** The socio-economic component of this WP has connections with (among others) the PROMO project (Perceptions and Risk Communication in Flood Risk Situations, BSIK Project Leven met Water) and ENSURE (Enhancing resilience of communities and territories facing natural and na-tech hazards, EU FP7 project). The hydrological/water management part is a direct continuation of various research projects that are carried out by KNMI, RWS and Deltares. In addition a link will be made with related research programs in Germany (KLIWAS), France and Belgium.

- **WP-2:** Strong links with ongoing research on fresh-salt water relations within various projects and programs such as the "Leven met Water" BSIK programme "*Leven met Zout Water*" project; the project "*Salinisation* and freshening of phreatic groundwater in the Province of Zeeland"; the Interreg projects Cliwat (on determining the effects of climate change on groundwater systems and through this on surface water and water supply, www.cliwat.eu), Climate Proof Areas and Scaldwin; the KfC project "*Demand and supply of* fresh water in the South-western part of the Netherlands : an exploratory investigation (viz. Meta-studie *Zuidwestelijke Delta*)"; the Waterhouderij in the Province of Zeeland (WINN project); and the EU Water supply and sanitation Technology Platform Pilot Programme Mitigation of Water Stress in Coastal Zones.

- **WP-3*:*** Strong connections to the COST network of Prof. T. Flowers/Prof. J. Rozema). The ongoing cooperation with Ben Gal, Russo, and co-workers (Gilat Res. Centre, IL) is particularly focused to combining the physical/hydrological aspects of agriculture under saline conditions with micro- and macroeconomic theory and pricing of water as a management tool. This aspect is brought into the research of project 3-1 in view of the reviews. Furthermore, project 3.1 & 3.3 are closely linked with the cooperation projects of Wageningen University and Deltares, and with Vervoort (Un. Sydney, AU), and Porporato (EPFL, CH & Duke Un., USA).

- **WP-4:** Strong connections to the EU-TECHNEAU network, the EU WSSTP Task Force MAR, and cooperation with Henning Prommer (CSIRO, AU) and David Pyne (ASR Systems, USA). Salinization of

- fresh water resources is a major research topic in the joint research programme of the Dutch drinking water companies. KWR carries out this research programme. Considering salinization, the research focuses on the following themes: a) dynamics of salinization of intake points and prevention; b) optimization of storage concepts, such as ASR; c) optimization of desalination techniques and minimization of the environmental consequences (e.g. brine injection).

- **WP-5:** The researchers involved in this work package are already involved in various climate related research project, both national as well as international. Through the network of the researchers involved there will be a direct relation with related work at the Copernicus Institute for Sustainable Development and Innovation (Utrecht University) and the research projects sponsored by the Next Generation Infrastructures Foundation (sub-program: flexible infrastructures)

- **WP-6:** The cases for The case study proposed within the hotspot Zuidwestelijke delta will be a scientific extension of the KfC project "Demand and supply of fresh water in the South-western part of the Netherlands : an exploratory investigation (viz. Meta-studie Zuidwestelijke Delta)" and the KfC project " Negotiating uncertainties: defining climate proofing and assessing associated uncertainties in the *Southwest Delta Region of the Netherlands"* . The case 'Haaglanden' will be connected to various research projects and policy studies in the region and take into account the results of previous KfC projects on the topic of self-sufficiency. The case 'Groene Ruggengraat' will continue the work as done in the studies "*Waarheen met het Veen*" and has a strong connection with the "*Groene Hart study*".

In addition to above we will use the extensive scientific networks of our lead researchers. This include, among others: IWA specialist group on climate change (KWR is secretariat of this group, the Delta-Alliance (Deltares and WUR are leading parties in this international network of Deltas under climate change) and the involvement of WUR, Deltares, KWR etc. in various FP6 and FP7 EU research projects. As mentioned before the research is set up to contribute to and to avoid overlap with the Delta programme. This can be well managed since Deltares and Alterra are also active in the study on fresh water supply within the Delta programme.