Summary

Climate change will affect the supply of fresh water to populations and economic sectors in many deltas around the world. Also the Netherlands will have to adapt to a growing mismatch between water demand and supply.
The central question is: what are opportunities and adaptation strategies for fresh water supply and water quality in the Netherlands, given the changing physical boundary conditions in evaporation, precipitation, river discharges, sea level rise and salt water intrusion? The focus is on regional and local solutions within the low lying parts of the Netherlands. In addition to droughts, the main threat to fresh-water availability in this area is salinisation. The proposed research focuses on how these regions can become more self reliant but also on what adaptation within the main (Rijks) water system can contribute to the region.

Regional strategies and measures are investigated in three directions: improving buffering and allocation of fresh water within the region by water management; using water technologies like underground storage, desalination techniques and re-use of local available sources (e.g. waste water); and adaptation of land use, agriculture and nature, to changing fresh water availability. Three case study areas are selected in agreement with the involved hotspot parties: ‘Haaglanden’ (fresh water supply for greenhousing and industry), ‘Zuidwestelijke Delta’ (horticulture and (underground) waterstorage) and ‘Groene Ruggengraat’ (nature and agriculture under increasing salinisation and droughts). Field measurements and modelling within the work packages directly focus on these three areas. In addition to research on specific measures, the hotspots will be supported to develop integrated robust and flexible strategies for fresh water supply for the case study areas. These integrated strategies not only contain a technical component but will also involve guidelines for dealing with uncertainty associated with the problem of droughts and salinisation. Both the physical system and the governance system are considered, the latter in close cooperation with KfC themes 7 and 8.

Overview of main research questions of on three levels

On the level of the overall theme

- The main research questions on a general level are:
- what is the potential of measures to either increase water availability or decrease water demand.
- how can effective regional adaptation strategies be built from these and other measures.
  and to what extent do these strategies contribute to a national solution for a climate proof freshwater supply?

On the level of work packages and projects

In **WP-1** there are two main research questions:

- What conditions (evaporation, precipitation, river discharges, sea level rise and related salt water intrusion) can be expected in the Netherlands as a result of climate change but also as a result of decisions on water management within the Rhine basin. In the associated project the main

research questions are: can new techniques, using ensemble predictions, statistics derived from long multiple year time series (opposed to individual characteristic years) provide better insight in boundary conditions and connected uncertainty. In addition to climate uncertainty what may be the possible effect of water management measures within the Rhine and Meuse basin.

- In addition how may the economic vulnerability or resilience of sectors depending on fresh water develop on different scales (international to the level of individual companies). The two most interesting scales are the international and local level. On the international level the question is: how may the Dutch agricultural sector develop compared to its international competitors under a changing climate? On the local level the question is how is the economic drought risk is perceived and what the prospects are to act.

WP-2 is focussed on the question: How will the spatiotemporal patterns in the fresh water availability in ground- and surface water in coastal lowland regions change due to climate change and what adaptation strategies can be implemented to sustain water-dependent functions in the future? The two projects in this work package aim at answering the research questions:

- What are the controls on the interaction between groundwater and surface water during dry periods that determine the spatiotemporal dynamics in water quality and how can these be represented in models? This understanding is vital to to quantitatively evaluate possible adaptation strategies.
- How do fresh water lenses in brackish-saline environments at different levels react to climate change and adaptation strategies, what are key factors, and how can results derived in case study areas be extrapolated to other regions?

WP-3 is focussing in three projects on three main questions:

- How salt tolerant are conventional and ‘saline’ cultures and natural vegetations?
- How should this dependency be quantified to account for the complexity of environmental conditions, non-chronic exposure to salt, soil types, geohydrology, and plant specific factors?
- How can we benefit optimally from differences in salt tolerance with regard to agri/horticultural and ecosystem management, ecosystem protection and restoration strategies, crop rotation schemes, fresh water allocation and saving, and specialized high profit markets?

WP-4 is investigating the potential of water technology for providing solutions for regional self-sufficiency in the fresh water supply in two projects. The first project is focussing on the LSR-ASR (Leaky Storage Reservoir combined with phreatic Aquifer Storage and Recovery) system, addressing questions like:

- What are the hydrological and chemical effects of LSR-ASR systems during the filling, storage and recovery stage, how can these effects be mitigated?
- How can a LSR-ASR system be optimized in order to also form a buffer against extreme annual anomalies in either supply or demand?
- How can ASR systems be combined with other uses (e.g. to store and recover desalinized water or water supply for cooling and/or heating purposes)?

In a second project questions are elaborated like:

- What is the availability and quality of the alternative water resources, and which purification techniques can be applied to make them fit for agricultural or industrial use?
- Are innovative desalination techniques feasible along with more common desalination techniques?
- How can we dispose of membrane concentrate (brine)?

WP-5 addresses the main question: how can the various uncertainties encountered when developing policies for long-term fresh water supply best be dealt with? Sub-questions which are elaborated in the projects include:

- What are the relevant uncertainties in characteristic regional fresh water supply situations to be dealt with in the Netherlands? What is their character, and how important are they?
- What analytical approach best suits the different uncertainties?
- what criteria can be relevant for choosing among these policy options, with a particular view to
- how they deal with uncertainties (flexibility? Least-regret? Robustness?)
- what general recommendations can be given for the selection of a preferred policy strategy to deal with uncertainties, depending on the situation characteristics?

In **WP-6** three integrating case studies are carried out. Central research questions in each case study are:

- Problem framing: do the involved scientists, practical experts and regional policy perceive the (growing) mismatch between freshwater supply and demand? What is the level of (dis)agreement about the sense of urgency to tackle this issue?
- Joint fact finding: what are the physical and socio-economic key indicators for climate proofing water supply, water use and impacts on the water balance?
- Co-production of knowledge: Designing and tailoring regional explicit adaptation strategies, including portfolios with measures to cope with salt and drought risks and to capitalise on new opportunities
- Joined evaluation of alternative strategies: identification of the (perceived) level of ‘no-regret’ of proposed strategies/measures