Applying knowledge in case studies

Work package leader : prof. dr. ir. W.A.H. (Wil) Thissen

Content

1 Description work package

1.1 Problem definition, aim and central research questions

In work package 6 we aim to identify viable adaptation strategies built upon scientific knowledge from WP-1-5 and practical experience in freshwater resources management. These strategies should consist of a mix of measures and interventions that aim to optimize water demand and water. During the execution of the research programme the interaction between the stakeholders and research activities within the other work packages will in particular be organized through WP-6 in the three integrating cases:

a) ‘Haaglanden’, viz. “Improving regional self support of Greenhousing and Industry in the Westland area”;

b) 'Zuidwestelijke Delta', viz. "climate proof, and sustainable water use in the southwest Dutch Delta area" and
c) 'Groene Ruggengraat', viz. "combined adaptation for agriculture and nature in the 'Groene Ruggengraat'.

For each case study a working group and steering group (waterboards, provinces) will be created consisting of relevant project leaders of WP1-5, stakeholders and key persons in relevant science-policy interfaces (programme office Zuidwestelijk-Delta, KNDW, programme office Waterkader Haaglanden). This working group is responsible for tuning stakeholder interactions (workshops, interviews, surveys. In each case study informal meetings are organized (frequency once a half year) to assure that practical experience in freshwater resources management is enriched with research results and the other way around. In addition a number of formal meetings with stakeholders will be planned.Researchers will be working partly on location at the office of relevant stakeholders (province, water board)

In the 3 working groups of the cases joint fact-finding (Eerman and Stinson, 1999) between involved scientists and practitioners and policy makers will be stimulated. In short, employing joint fact-finding means addressing a factual dispute by forming a single fact-finding team comprised of experts and decision-makers representing both sides of the dispute (Schultz, 2003). The factual dispute(s) to be discussed in the workshops is built upon the main objective of the research proposal, the aim to find solutions for the growing mismatch between freshwater supply and demand in the short- (2015) and long term (2050/2100). Amongst others, disputes to be discussed are:

- The level of (dis)agreement about the sense of urgency to tackle this issue (problem framing)
- Water demand management versus water supply management (costs and benefits)
- The (perceived) level of 'no-regret' of proposed strategies/measures on case study level
- Resilience approach versus Robustness approach (in co-operation with WP-5)

Lessons learned in the field of 'action based research' will be embedded into our approach in case study 'Haaglanden' in collaboration with KfC theme 7 (Erasmus University, Arwin van Buuren).

This tailor-made local approach has the risk that water scarcity problems are transferred from one region to the other. Work package 6 aims to identify these risks of problem shifting, in close collaboration with work package 1 and 5. In collaboration with WP1 (Anne van der Veen), KfC project " Negotiating uncertainties: defining climate proofing and assessing associated uncertainties in the Southwest Delta Region of the Netherlands" and KfC theme 3 (Rural Areas) consultation of stakeholders in fresh water resources management (in particular agriculture, nature conservation) are planned. Also TNS-NIPO and ZLTO within (a selection of) the case studies will be invited to these consultations. These consultations include internet surveys and interviews. The general objective is to assess how resilient individual agricultural entrepreneurs are regarding economic drought and salinity damage and how they deal with uncertainties. The results are used for Agent-Based modelling (KfC theme 3), Exploratory Modeling/Analysis (WP-5) and guidelines for dealing with uncertainties in negotiating processes (KfC project Negotiating Uncertainties in collaboration with WP5).

Deliverables

Each case study has its specific deliverables. In addition it is our ambition to wrap up and to integrate the results from the case studies in co-operation with work package 5. The involved PhD's are stimulated to become involved in multi-disciplinary publications based upon the results of the case studies.

- ∇ Qualitative Description of local portfolios with measures to cope with salt, flood and drought risks supported by both scientific knowledge, practical expertise and treatment of uncertainties
- ∇ Quantitative assessment of (future) freshwater supply, fresh water demand and the water balance on local level (salinity and quantity).
- ∇ For each case study a multi-author popular article will be published
- ∇ 1 peer reviewed article that will reflect on the level of achieved inter/multi/transdisciplinarity within the 3 case studies and the usefulness of the chosen approach
- ∇ Applied Prototype experiments in the field of water technology (desalinization concepts, brine treatment and injection techniques, reuse of waste water, storage of surface freshwater in aquifers)
- ∇ A paper on the generic aspects of strategies towards a sustainable water management system in low lying areas

1.2 Interdisciplinarity and coherence between the projects

For each case study knowledge regarding measures will be combined and tailored to the local circumstances in dialogue with local experts and stakeholders. Two policy paradigms are currently used in policy making regarding approaches to climate proof fresh water resources management in the Netherlands (Design National Water Plan, 2008):

a) Resist impacts of climate change on fresh water resources
b) Cope and live with the impacts of climate change on available fresh water resources.

Within those two main policy paradigms combinations of measures are sought that increase the robustness and/or resilience of freshwater supply and the use of water (. A second approach, labeled as adaptive policy making, explicitly considers and includes options for deliberate adaptation as the future evolves. In each of these regions similar timeframes for the main interventions to achieve are used, i.e. short term (2009-2015), medium term (2015- 2050) and long term (2050-2100).

A project team with representatives of all consortium members and WP's takes care for integration of the results of the 3 projects, including dissemination of generic lessons learned that are also worthwhile for other case studies within KvK and other delta's. The project team takes care for the co-operation with the other work packages and with other KvK research projects.

1.3 Stakeholders

Project 6.1: *Province Noord-Holland, Province Zuid-Holland. Province Utrecht, Waterschap Schieland en Krimpenerwaard, LNV, DLG, Programmabureau Groene Hart*

The Dutch government decided in 2009 to invest 113 million Euro in the peat meadow areas during the period 2010- 2015 (in Dutch: Uitvoeringsprogramma FES Westelijke veenweiden and Randstad 2040:

inrichting van een Groene Ruggengraat). The investments aim to synchronize spatial claims for nature, agriculture, construction and water management, supported by knowledge developed by national research programmes (Habiforum, Leven met Water) and applied by the programme offices Groene Hart (www.groene-hart.nl), Laag-Holland (www.laagholland.nl) and project Hollandsche Ijssel (www.schonermooier.nl). The available science-policy interfaces and stakeholder networks of these organisations will be used in project 13.

Project 6.2: *Province Zeeland, ZLTO, DLG, Provincie Brabant, Waterschap Brabantse Delta*
This project will make use of the stakeholder networks of two the Knowledge Network Delta Water (KNDW) and the program office ' Zuidwestelijke Delta' (www.zwdelta.nl) . The programme office ' Zuidwestelijke Delta' falls under responsibility of a steering committee that include high-level policy makers of the ministry of V&W, regional water boards and provinces.

Project 6.3: *Waterkader Haaglanden, Province Zuid-Holland, Waterschap Delfland, Glaskracht, NLTO, Waterschap Hollandse Delta, PPO Glastuinbouw-Naaldwijk (Wageningen UR)*
In project 15 an advisory board comprised of local experts will be established in which above mentioned institutions will be involved. Workshops and interviews with stakeholders will built upon the established public-private partnerships by Water Framework Haaglanden (www.waterkaderhaaglanden.nl), in Dutch 'Waterkader Haaglanden'. This is a cooperation between the water authority Delfland Water Board, the Province of South-Holland and the City Region of Haaglanden with its nine municipalities.

2 Project 6.1 Case study Groene Ruggengraat – Climate proof water and land use in coastal meadows of the Netherlands

Project leader: Jeroen Veraart

2.1 Problem definition, aim and central research questions

Much of the world's population lives in coastal areas and delta regions. Fertile soils, presence of water resources and transport possibilities make deltas ideal settling areas. On the down side they are inherently vulnerable to natural hazards. Expanding economies and the intensification of agriculture place considerable pressure on fresh water resources and ecosystems, such as coastal meadows. The coastal meadows in the Netherlands are characterized by the interplay between urban and rural developments. The urban agglomerate that borders the coastal meadows is commonly referred to as Randstad. The water-rich meadows, referred to as ' Groene Hart', combine the functions of agriculture (mainly dairy farming and along the borders greenhouse horticulture), nature, and recreation for about 5 million people. It is a cultural landscape characterized by water systems such as lakes and pools as well as numerous ditches and canals. As a result water management in this area is complex. In addition the area is on the short term (<2025) under pressure due to expansion of the Randstad periphery, soil subsidence (up to 1 cm/year), the demand for for water retention areas, and water nuisance related to climate change (Woestenburg, 2009; Querner et al., 2009).

A rising sea level imperils on the long-term (>2050) the fresh water availability in this region as salt water penetrates further inland via the rivers and through the subsoil (Deltacommissie, 2008). To reduce the impact of salt water intrusion for agriculture the amount of freshwater necessary to flush out saline water will increase.Warm dry summers with freshwater shortages will occur more frequently according to two of the four KNMI climate change scenarios (van den Hurk et al., 2006). Higher temperatures and the changes in fresh water availability will change the conditions for terrestrial and aquatic ecosystems in the coastal meadows. Some species and certain ecosystems will not be sustainable under the changed conditions; new (exotic) species may flourish. Policies, such as Natura2000 and the EU water framework directive that are concerned to preserve present conditions and species will probably be neither sustainable in the face of climate change. Agriculture and horticulture will encounter both opportunities and risks. The foreseen changes in rural and climate European policies, such as a new directive for emission trading (2008) might allow dairy farmers on low-lying peatland to diversify and to climate proof their activities, including the reduction of greenhouse gas emissions In future post-Kyoto policies this type of ecosystem services that increases the resilience of rural landscapes to climate change (Werners, in press; Werners, 2009) might be awarded in (subsidized) economic income.

Aim: The project investigates/evaluates local cross-sectoral strategies (agriculture, nature conservation, drinkwater production)in the Dutch coastal meadows that are aimed to minimize the increasing gap between regional supply and demand of freshwater, given the context of climate change and trends in water demand. Evaluation criteria for these local strategies include resilience, robustness and flexibility. Those criteria are applied to assess risks for salt damage, drought damage and greenhouse gas emissions for agricultural practices and biodiversity.

Research questions

- ∇ Under which spatial and season salt-freshwater gradients and supply/demand scenario's it is possible to fulfill both socio-economic water demand (agriculture, drinkwater production) in conjunction with nature development and biodiversity policies in the coastal meadows?
- ∇ What are the implications of the proposed local adaptation strategies by scientists and stakeholders for the short-term policy objectives for the region as formulated by the European Water Framework Directive, Bird directive and Natura2000?

2.2 Approach and methodology

Approach:

Step 1: Problem framing: assess the future (perceived) gap between freshwater supply under 2 different baseline scenarios for future water demand (without interventions) on local level for biodiversity conservation, agriculture and drinkwater production.

Step 2: Selection and quantification of key indicators to assess the mismatch between freshwater supply and demand under the baseline assumptions (without intervention) in order to assess the magnitude of the (future) mismatch.

Step 3: Design of 2 alternative futures, that include a local portfolio of measures (water management, water technology and land use change) aimed to reduce the identified mismatch from step 1. The alternative futures are based upon the following water management paradigms:

- Resist impacts of climate change on fresh water resources
- Cope and live with impact of climate change on fresh water resources

The local portfolios of measures will also be discussed in an international workshop for which people will be invited that are involved in management of coastal meadows in other countries.

Step 4: Those alternative futures are evaluated based upon the selected key indicators and described baseline scenario's (step 1).

All 4 steps are executed in dialogue between the scientists from the consortium and the regional experts and policy makers. In this way it is possible to identify differences and consensus in perceptions regarding future drought and salt damage risks (Euro/ha) for biodiversity and socio-economic functions in the Dutch coastal meadows (i.e. joined fact finding). The following timeframes are used:short term(2009 – 2015), Medium term (2015 – 2050) and Long term (2050 – 2100).

The project will build upon the results, regional land use/water management scenario's and public-private networks of the programme "Waarheen met het Veen" (Woestenburg, 2009), as well as on the results of the so-called Groene Hart study (forthcoming). Therefore it is chosen to apply the approach on local level. Possible local case studies, selection will be done in dialogue with the hotspots, include: Reeuwijkse plassen, Zevenhovense polder, Nieuwkoopse plassen, Zegveld, Midden Delfland and Waalblok. Issues of problem shifting of water scarcity issues from one region to another, suboptimal outcomes for the meadow lands as a whole will be identified. However, the (quantified) impact of those type of scaling issues are beyond the scope of this study and will be addressed in the National Delta programme.

The methodology includes:

- Expert judgment by scientists, practical experts and regional policy makers in workshops. Those workshops aim also to support foreseen modeling activities in work package 1,2 and 3. All steps in the approach are supported by desktop studies and literature survey.
- By means of (interview) surveys and spatial analysis of (changes in) land use types (nature, agriculture, recreation), land users' support for certain adaptation portfolio's and their attitude towards ecosystem service provision, will be identified. The results of this survey will be used to model the future distribution of different farmer and nature conservationist types with agent-based modeling (Bakker and Doorn, 2009; Filatova et al., 2009) in co-operation with KvK theme 3.

Disclaimer: the methodology described gives a rough outline of the project. The final research ambition (i.e. number of scenarios, number of key indicators, number of time frames and number of publications) will depend on the available budget, currently discussed with the involved stakeholders.

2.3 Scientific deliverables and results

1. The selection and quantification of the key indicators to assess the mismatch between freshwater supply and demand under different scenarios. The will be described in 1 or more scientific multi-author papers (inclusive the involved PhD from other projects) as this generic result is also usefull for other coastal meadow areas in the world.

2. This project will contribute, together with project 14 and15 and workpackage 5, to a peer-reviewed multi-author paper that will reflect on the level of achieved inter/multi/trans-disciplinarity and the usefulness of the chosen approach.

3. This project provides on a local scale opportunities to improve models that are part of the National Hydrological Instrumentarium (report)

2.4 Integration of general research questions with hotspot-specific questions

The approach is designed in order to support hotspot specific questions as much as possible. The local cases will be selected in dialogue with the hotspots. The two main research questions (see section A) support raised questions by Hotspot Haaglanden, Hotspot Rotterdam, province Utrecht, Zuid-Holland,waterboard Schieland and Krimpenerwaard, water board Hollandse Delta and STOWA about the implication of climate change and changes in socio-economic water demand for the Water framework directive and Natura2000.

2.5 Societal deliverables and results

For each selected local pilot (maximum 3) a description of portfolio's of operational measures to climate and salt proof freshwater demand and supply, tailored to local and regional circumstances will be delivered (**3 reports**). Not only the reports but also the set up of the project will provide both regional and national authorities with a selection of viable strategies to contribute to regional self-sufficient and climate proof water supply system.

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3 Project 6.2 Case study Haaglanden – Towards a more robust, self-sufficient fresh water supply of the Haaglanden region

Project leader: Dr. Ir. M.A.A. Paalman (KWR)

3.1 Problem definition, aim and central research questions

Problem definition

Climate change projections for the Netherlands reveal the risk of periodic shortage of fresh water supply in the future (Loaiciga *et al.*, 1996). During periods of summer drought, the Haaglanden region will depend more heavily on surface water supply from the major rivers. However, due to the effects of climate change, the intake water from the Rhine/Meuse basin may become (periodically) brackish due to periods of low river discharge and salinity pressures from rising sea levels (Middelkoop *et al.*, 2001). In addition, in order to increase the ecological sustainability of the Deltaworks region, structural management alterations are foreseen and this can have profound implications for fresh water availability in the Zuidwestelijke Netherlands (e.g. Haaglanden region). In order to ensure economic sustainability and growth in the area, it is crucial to have a sufficient continuous supply of fresh water.

Aim

The goal is to promote regional water self-sustainability in an area of high intensity industry (Rotterdam region) and greenhouse horticulture. This research project will identify and evaluate the feasibility of alternative regional sources of fresh water in a deltaic, saline environment. In addition, adaptations to or optimization of current water supply infrastructure will be analyzed given the projected impacts of climate change. To accomplish this, innovative technological methods will be assessed and implemented on pilot-scale if appropriate.

Research questions

The main research questions have been designed to address general issues identified in work packages 1, 2 and 4 in a case-specific environment (Haaglanden).

The first main research question is: How can we make the Haaglanden region's water supply more self-sufficient?

- What is the potential of alternative sources for local or regional freshwater supply and what is the development of the demand of fresh water by the sectors? (project 4.2)
- What are the PRO's and CON's of utilizing each of these sources in terms of availability, continuity, water quality, transport, treatment technology, costs, environmental impact and regulations? (project 4.2)
- What proactive water management measurements can be taken in periods of drought?
- How will salinity and groundwater-surface water interactions be affected by climate change?
- How do we improve the buffering capacity and storage of fresh water? This question will be answered in cooperation with project 2.1 and 4.1.
- What innovative disposal solutions exist for the saline residue (brine) that is generated as a byproduct of desalination? (project 4.2)

The second main research question is: How the main water system in the future can contribute to the regional fresh water supply of Haaglanden? (project 1.2)

- How will climate change affect fresh water (salinity) at the major intake points of surface water (Gouda and Bernisse)?
- Will there be an adequate supply of water from the main surface water network system to meet demand in Haaglanden?

3.2 Approach and methodology

Disclaimer: The methodology described below just gives an outline of the research possibilities. The final research ambition will depend on the project's budget, which is not defined yet as the amount of co-financing generated by the different stakeholders is still unclear.

Approach

The study focuses on ways to obtain a more regionally self-sufficient water supply that is less dependent on surface water (the main river system). In particular, this will focus on the greenhouse and industrial sectors, as they are the most important economic activities in the area. The approach will focus primarily on using the system's own regional water sources (groundwater, surface water, rain water, waste water) more efficiently. This will result in a more sustainable, climate-proof water system with balanced supply and demand. This approach and methodology will be further developed in coordination with regional stakeholders and through consultation with a project advisory board comprised of local experts (Province of South Holland, Waterboard of Delfland, Municipality of Westland,LTO/Glaskracht (greenhouse sector)).

Methodology

1. How can we make the Haaglanden region's water supply more self-sufficient? (desk and field study)
    - Describe the current and future situation of the greenhouse and industrial sectors in the Haaglanden region (based on available literature and interviews with experts).
    - Inventory of the current and future fresh water demand in the Haaglanden region. We will base this inventory upon available local knowledge and experts from WUR with relevant experience (A.van der Maas et al, 2009).
    - Inventory and quantify primary and alternative sources of fresh water in the Haaglanden region (brackish groundwater, reuse of wastewater, rain water, use of excess groundwater of former DSM Delft). Local expert knowledge from the Delfland Water Board will be highly valuable for this inventory.
    - Perform desk research on the technological opportunities to make the various sources of water suitable for surface water and the greenhouse and industrial sector as Memstill
    - Assess the feasibility of the relevant alternative water sources in terms of availability, continuity, water quality, treatment technology, costs, laws and regulations.

- ∇ Study the possibilities of aquifer storage and recovery (ASR) and other fresh water buffering techniques in a brackish groundwater environment (in association with Projects 2.1 and 4.1).
- ∇ Further develop a groundwater-surface water model to quantify changes in the supply of fresh water, especially in dry periods, in the Haaglanden region as a result of climate change (together with WP 2.2).
- ∇ Inventory of past and current projects on brine in the region (eg. study by the province of South Holland). The results of these projects will be reviewed in terms of geographical feasibility and technological aspects.
- ∇ Based on the review of past and current projects, identify potential brine disposal techniques that could be implemented on pilot-scale in Haaglanden. Possible examples include evaluation of brine injection into confined saline aquifers, and the potential of water technology (crystallization) to produce a solid end product which may be reused for industrial applications (the “no-waste” concept of TNO).

2. How may salinity levels at the major intake points of the main water system (Bernisse, Gouda) vary over time, according to different climatic and hydrologic scenario’s and upstream (transboundary) water management? What will be the consequences of these projected variations for water supply to the Haaglanden region?

3.3 Scientific deliverables and results

The proposed research will result in the following deliverables:

1. Quantification of the demand and regional availability of fresh water in the Haaglanden region
2. Identify and quantify the potentials and hurdles of (innovative) water treatment technology (desalinization, transport system, Memstill technology).
3. Ditto of innovative brine treatment technology like the crystallization process and brine injection into saline confined aquifers.

Deliverables will be published as a scientific report (items 1-4). In addition, several publications in national, professional journals are anticipated.

3.4 Integration of general research questions with hotspot-specific questions

A report from the steering committee of the Zuidwestelijke Delta to the Secretary of State on Water Management strongly recommends research to improve regional water self-sufficiency (Stuurgroep Zuidwestelijke Delta, 2009). Improving regional self-sufficiency in water supply is an important challenge to all hotspots in brackish water environments that face potential fresh water shortages (Zuidwestelijke Delta, Haaglanden, Rotterdam, Schiphol region and the Waddenzee). The hotspot areas Zuidwestelijke Delta and Haaglanden are particularly interested in research that could enhance the self-sufficiency of their water supply (Vries, A. de, 2009).

3.5 Societal deliverables and results

The results of the research will provide regional and national authorities with a selection of practical and effective strategies to contribute to regional self-sufficient water supply. As such, these authorities can utilize the knowledge to design robust adaptation plans that will mitigate the effects of climate change on water resources. This will help ensure long-term environmental and economic sustainability for regions by providing a continuous, secure source of fresh water.

The provision of a regional self-sufficient water supply in saline environments is important for all deltaic and coastal regions. The knowledge and concepts generated in this research can be utilized to help develop alternative water supply in similar regions worldwide. In addition, newly-developed or optimized processes for treatment and disposal of desalination brine with minimal environmental effects are relevant for all countries that operate desalination plants (Middle Eastern countries, Spain, Australia). Addressing this environmental issue could open up new possibilities for the wider implementation of desalination plants globally.

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Remark: see additional references at the relevant projects (WP1, WP2 and WP4)

4 Project 1.1 Case study Zuidwestelijke Delta – Climate proof, and sustainable water use in Dutch Delta area

Project leader: dr. A.C. (Arjen) de Vries

4.1 Problem definition, aim and central research questions

The South-western Delta consists of the estuaries of the rivers Rhine, Meuse and Scheldt. Interactions between sea, rivers and land are characteristic for the whole area. The area is important as strategic freshwater reservoir for the rural area to the east, for river-discharge regulation (peak discharges of the Rhine-Meuse are diverted from the port of Rotterdam), for recreation (aquatic and cultural), aquaculture (shellfish, lobster, etc.), nature (especially relict intertidal areas), and as gateway to the port of Antwerp (Westerschelde). While the Deltawerken are still an international icon for Dutch water management, current land-use and water-management plans put emphasis on their adverse environmental impacts (water quality), as well as prospected climate change. Currently water management strategies and land-use plans are reconsidered in order to minimize flood risks, optimize freshwater availability, reduce salinisation, and improve water quality and biodiversity, as most recently described in the National Water Plan (2008). Two main fresh water basins, constructed as part of the Delta Works, are the Haringvliet and the Volkerak-Zoom lake. Large parts of the Delta have no direct access to fresh water, and are solely depend on rainfall and natural storage.

The major challenge is to develop the southwest part of the Netherlands in a sustainable manner, including the restoration of the estuarine dynamics under a changing climate, thereby safeguarding the freshwater supply for agricultural and other uses. A number of possible approaches have been identified:

- supply follows demand, i.e. guarantee fresh water supply artificially by separation from the natural environment (external supply)
- demand follows supply; i.e. adaptation of water-dependent sectors to the natural environment
- a combination of 1 and 2 including the applications of innovative technology

The current project focuses on an area without direct access to fresh water reservoirs. However, given the expected higher water demands in future and the impact of especially salinization, there is a clear need for a strategy towards a sustainable and self-reliant water management system under climate change. For the content the project continues to develop further insight in the processes of salinization and possible effective measures, both at the regional and local scale. The project is based on results from projects such as ‘Living with Salt Water, (www.levenmetzoutwater.nl), the Meta-studie (De Vries et al., 2009), that made a first reconnaissance of the existing and expected fresh water situation of the Zuidwestelijke delta and work of Oude Essink (2007) and Post (2004) on the physical aspects of salinization processes.. Although the case focuses on a typical Dutch area, the projects has a clear international relevance. Many low lying Deltas face very similar problems such as increased salinisation (both internal and external) and increased pressures. The results of the study give insight in the physical processes and on strategies on how to deal with the occurring issues.

Aim: The current project investigates whether new approaches to the supply and demand of fresh water are desirable or required in the context of a changing environment, in an area located in the South-western Delta. This 'freshwater claim' will be compared with other water, agricultural and climate policy objectives in this area. The exact location of the project area within the South-western Delta will be identified in a later stage.

Research questions

The main research questions have been designed to address the more general issues as identified in the other work packages.

1. How to develop the project area in a more sustainable manner, including the restoration of the estuarine dynamics under a changing climate, thereby safeguarding the freshwater supply for agricultural and other uses and making the dependency on external water supply smaller.
2. What is a feasible strategy to reach that goal and what are viable options for land use, water-management, and water-technology for the long-term future.

4.2 Approach and methodology

Approach

The study focuses on ways to reach a more regionally self-reliant water supply system that is less dependent on external freshwater supply. It focuses primarily on different alternatives to utilise the areas own water resources (surface water, groundwater, rainfall, waste water) more efficiently or for example through storage. Based on the existing hydrological system and the expected changes in terms of climate change and land use, a strategy will be developed that will result in a sustainable, climate proof water system with balance between supply and demand. This strategy will be further developed in an open dialogue with the different stakeholders and through consultation with the project advisory board. The board will include experts from the Province of Zeeland, Province of Brabant, Water Board ZuidHollandse eilanden, Water Board Brabantse Delta, and ZLTO (agricultural sector).

Results from other work packages will be input for the current project. Also experts and researchers from the other work packages will participate actively. The methodology described gives a rough outline of the project. The final research ambition and budget will depend on the results of ongoing discussion with the involved stakeholders. Also the specific research area within the Zuidwestelijke Delta will be defined at a later stage. However, it will probably include the area of Zuid-Beveland

Methodology

1. Baseline study
    - Hydrological system analyses, including all possible water resources mentioned before, considering both water quantity and water quality
    - Inventory of actual and (expected) future water demand and supply for the different sectors
    - Inventory of expected changes in fresh water supply, due to climate change. This inventory includes both internal and external salinisation processes.

- Inventory of potential solutions offered by water technology (e.g. desalination, effluent reuse, brine disposal options)

2. Strategy development
    - Development of a strategy for a sustainable, climate proof water system, based on the baseline study and stakeholder consultation
    - Inventory of portfolios of area specific measures (both technical and institutional)
    - Consultation with the stakeholders on strategy and measures.

A number of specific aspects will be looked at, such as:

- ∇ Opportunities for self-reliance of the horticulture sector in Zuid- Beveland (area located in the South-western Delta) through storage at the local scale
- ∇ Nutrient load from the groundwater to the surface water

4.3 Scientific deliverables and results

The proposed research project will result in the following deliverables:

1. Feasibility study of a regional self-reliant water supply, for a region in the South-western Delta.
2. Combined analyses of other case studies to the crucial factors for self-reliance
3. Opportunities for self-reliance of the horticulture sector, including possible measures
4. Insight in the physical processes and on strategies on how to deal with a changing environment under climate change and increased pressures in low-lying delta areas.

4.4 Integration of general research questions with hotspot-specific questions

A report from the steering committee of the Zuidwestelijke Delta to the Secretary of State on Water Management, strongly recommends research for improving regional water self-sufficiency (Stuurgroep Zuidwesterlijke Delta, 2009). Improving regional self-sufficiency in water supply is an important responsibility to all hotspots in brackish water environments that face potential fresh water shortages (Zuidwestelijke Delta, Haaglanden, Rotterdam, Schiphol region and the Waddenzee). The Zuidwestelijke Delta and Haaglanden hotspots are particularly interested in research that could enhance the self-sufficiency of their water supply.

4.5 Societal deliverables and results

The results of the research project will provide regional and national authorities with a selection of viable and effective strategies to contribute to a regional self-sufficient water supply system. As such, these authorities can utilize the knowledge to design robust adaptation plans that will mitigate the effects of climate change on water resources. This will help ensure long-term environmental and economic sustainability for regions by providing a continuous, secure source of fresh water.

The provision of a regional self-reliant water supply in saline environments is important for all deltaic and coastal regions. The knowledge and concepts generated in this research can be utilized to help develop alternative water supply in similar regions worldwide.

4.6 Most important references

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