Water Systems and Global Change (WSG) Group)

WSG Group

August 2020

WAGENINGEN
UNIVERSITY & RESEARCH

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Welcome to WSG

WSG is a solution-oriented multidisciplinary research group focusing on water systems and global change. We are one of the chair groups in the Environmental Sciences Group of Wageningen University and Research.

This report gives an impression of our teaching and research. It gives an overview of our courses, PhD candidates, and projects.

Our office is in the C wing of the Lumen Building. You are welcome to visit!

Our mission:

To create new knowledge to contribute to sustainable water systems in a changing global environment.

Our vision:

Sufficient, clean and climate-proof water for society and nature.

Too much, too little, too dirty: opportunities and threats in water for society and nature

Education of the Water Systems and Global Change Group

Solution-oriented science for sustainable water system management, that is our approach. We analyse and assess the impacts of climate change and population growth on water systems and propose and test adaptation strategies. We use simulation models, earth system observations, scenario analysis and field studies and we invite students from different backgrounds, and skills and interests to take part in our courses and research.

The Water Systems and Global Change chair group offers several BSc and MSc courses and PhD Programmes. WSG master students can specialize on water systems and global change by following:

- the Adaptive Water Management in the Master International Land and Water Management and
- thesis track Water Systems and Global Change in the Environmental and Climate Change master programs.

Courses coordinated by WSG are:

- Disaster-Proof Planning and Preparedness in Water Management
- Integrated Water Management
- Climate Change Adaptation in Water Management
- Adaptation to Climate Change
- Design of Climate Change Mitigation and Adaptation Strategies
- Climate Smart Agriculture
- Modelling Future Water Stress

Research

The Water Systems and Global Change (WSG) group aims to improve the understanding of anthropogenically driven changes in water cycles in relation to interactions between climate-, water-, energy- and agricultural systems.

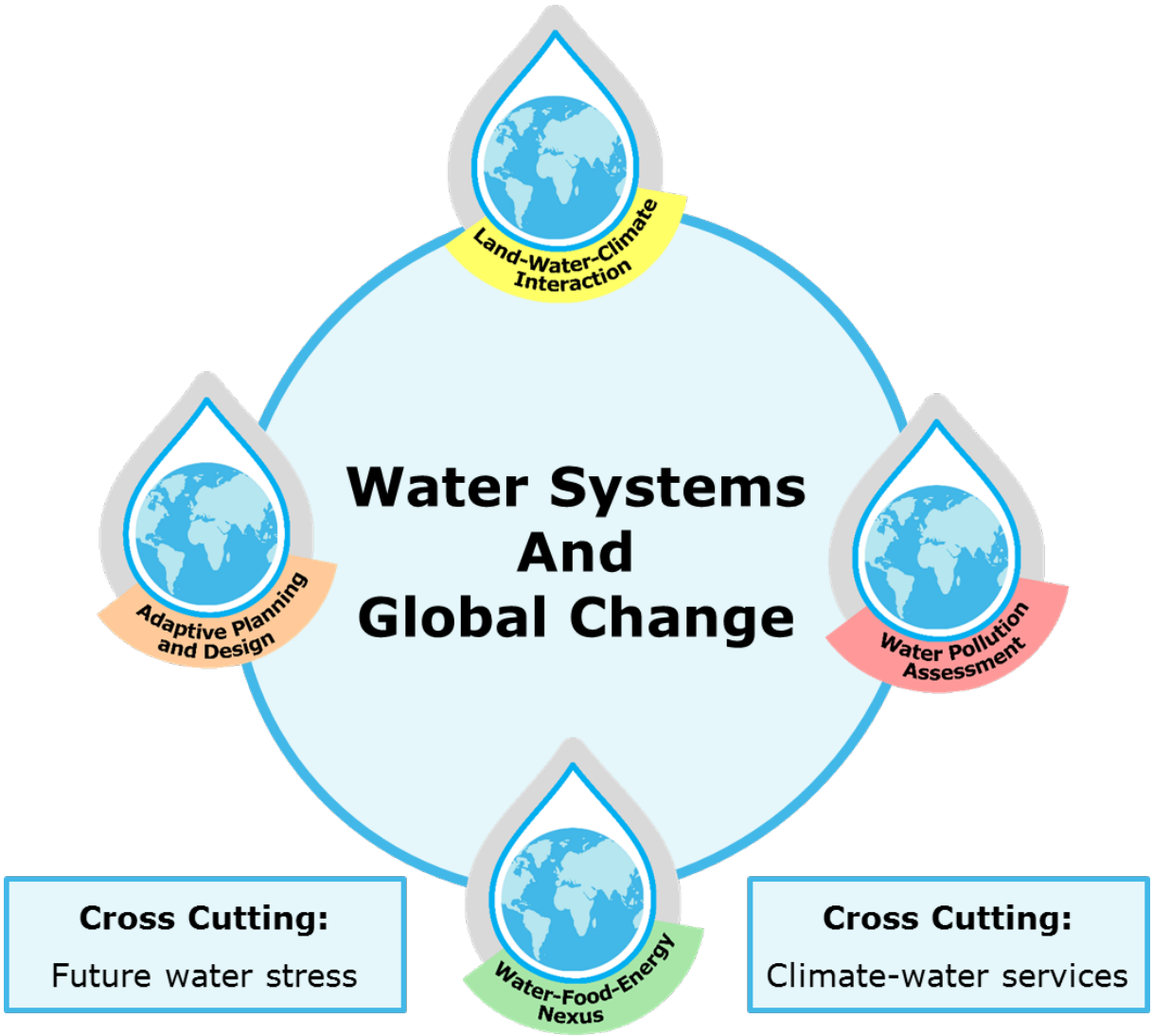
We identify four main research lines and two cross-cutting researches (see illustration).

Main research lines:

1. Land-water-climate interactions
2. Water-food-energy nexus
3. Adaptive planning and design
4. Water pollution assessments

Cross-cutting research:

1. Future water stress
2. Climate-water services

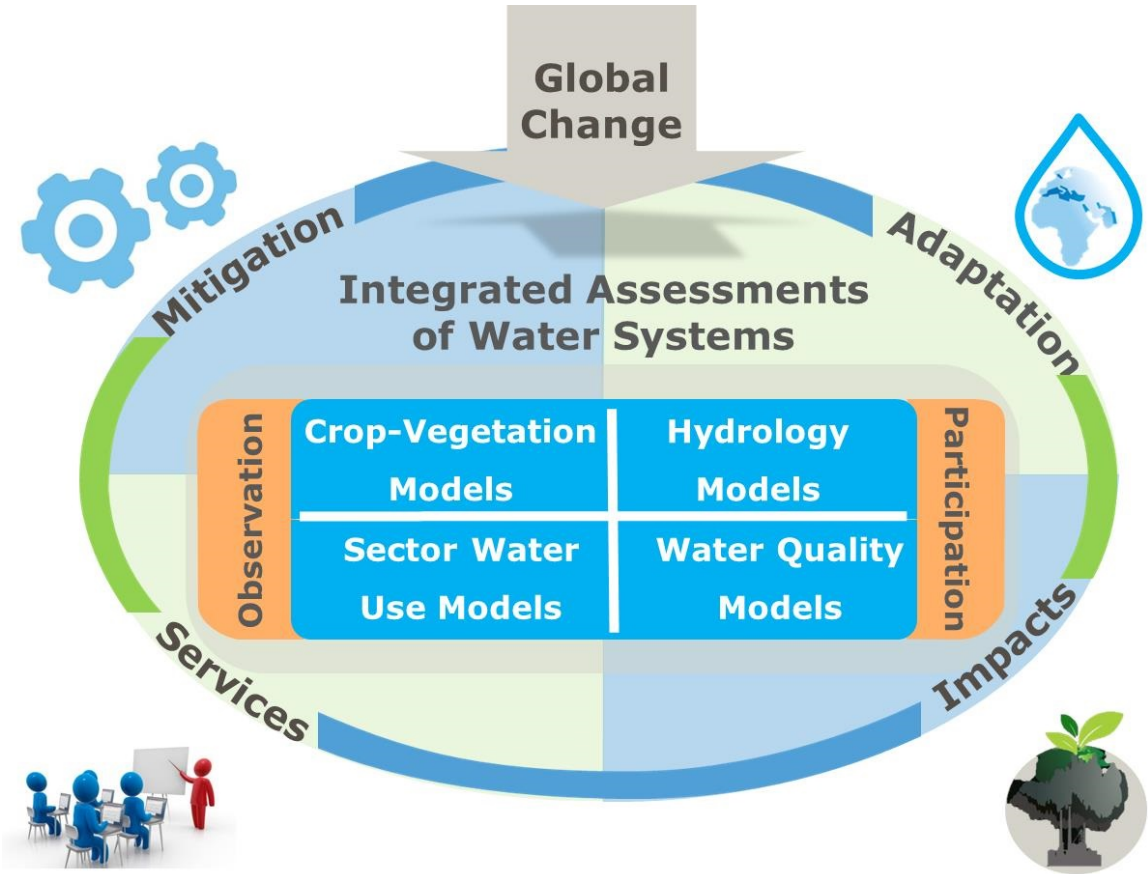


Research Framework

We perform integrated assessments of water systems, in which we integrate knowledge on water systems and global change. To this end, we use a variety of models and observations. We combine modelling analyses with participatory approaches. Our water assessments focus on:

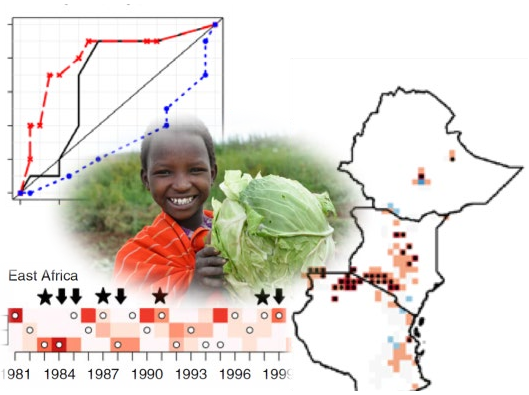
1. The effect of changing global drivers on water systems
2. Adaptation and
3. Mitigation strategies, comprising of novel approaches such as adaptive water management and ecosystem-based adaptation , and
4. Climate-water services.

We thus take an integrated approach across the water, food and energy systems at multiple spatial and temporal scales.



Land-Water-Climate Interactions

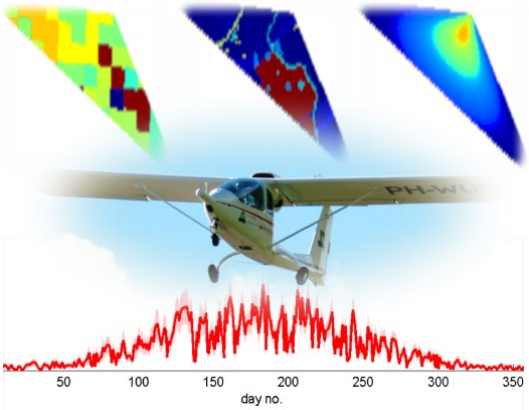
This theme focusses on dynamic feedbacks and interactions between water, carbon, and climate change, modelled and observed at mostly regional scales. We study the effects of climate change on natural vegetation and crops, but also the reverse i.e. the effects of large scale land use (change) on climate. Thus we aim to contribute to better exploit the potential of climate while respecting its constraints.



We use crop-, vegetation-, water models like WOFOST and LPJ to study the effects of climate change on the productivity of crops and the resilience of carbon stored in natural vegetation. We assess and improve the predictability of seasonal crop forecasts and long-term vegetation projections.

We use coupled land-atmosphere models like RAMS/WRF to study the effects of large scale irrigation and urbanization on rainfall recycling mechanisms.

Both require good knowledge on coupled evaporation – carbon exchange mechanisms in vegetation. Measurements at regional scales i.e. airborne flux measurements and remote sensing help us to improve parameterizations and scaling issues.

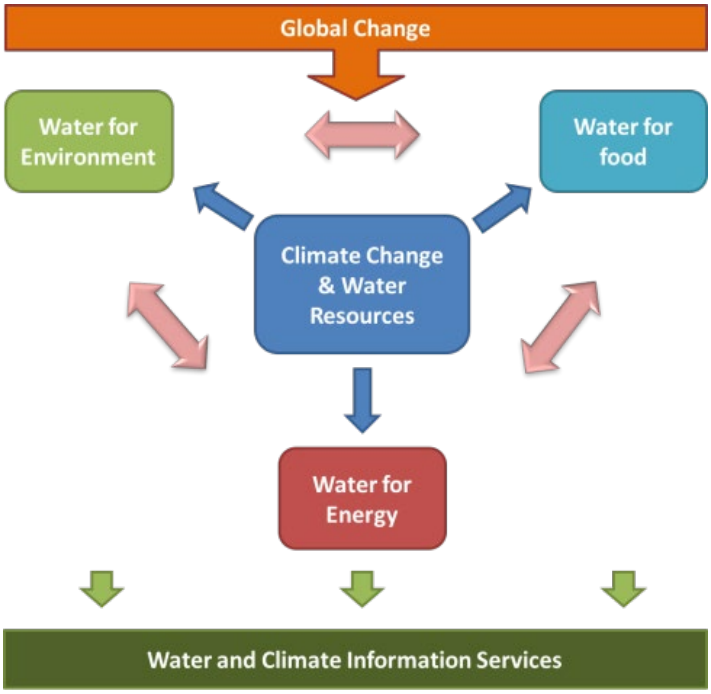


Water-Food-Energy Nexus

This theme focusses on analysis of how global change affects the links between the water, energy and agricultural sector. We especially address the question of how future water changes in climate and water demand affect trade-offs and synergies between water for energy, food and environment. To address these issues we develop integrated water modelling systems combined with large scale observational databases on water demand, availability and quality.

Currently we are working on how future changes in water systems affect the competition for water between the energy, agricultural and environmental sectors. In the agricultural sector, we focus mainly on irrigation water demands, and within the energy sector we focus on water for hydropower, biofuels, and cooling water needs of thermoelectric power plants. To improve trade-off analyses and assure that future water use is sustainable it is necessary to also quantify the water needs for the environment. To do this we developed an improved method for quantifying large environment flow requirements. The aim is to include this quantification in our modelling systems to improve water use analyses and to develop improved future water and land use scenarios.

The results of our modelling experiments are used to develop climate information services at different spatial scales and for a wide range of users. Our climate information services are developed in close collaboration with users and a wide range of other partners.



Adaptive Planning and Design

We analyse, assess and design strategies and plans to cope with impacts of global change. Our research covers dynamics in long term planning (adaptation turning points, adaptation pathways), innovations in coastal management (nature-based, multifunctional flood defences, building with nature), monitoring and analysis of real-life experiments (climate proofing of catchments) and development of hydro-meteorological information services.

Water Pollution Assessments

The availability of clean water is at risk across the globe. Water pollution poses a threat to ecosystems and society. A multi-pollutant modelling approach can help to better understand and manage water quality issues.

We develop multi-pollutant models of causes, effects and solutions of future water stress, while accounting for water demand, water availability, and pollution in rivers, lakes, reservoirs and coastal seas. Many pollutants have common sources and multiple impacts. A new generation of models is needed to explicitly address the combined exposure of surface waters to multiple pollutants. Such models could serve as a basis for integrated water quantity and water quality assessments. In Wageningen, we co-develop such models, focusing on water quantity (the VIC model) and water quality (nutrients, pathogens, plastic, salinity, toxic chemicals, etcetera) (Figure 1). We develop global models, but apply them on multiple scales.

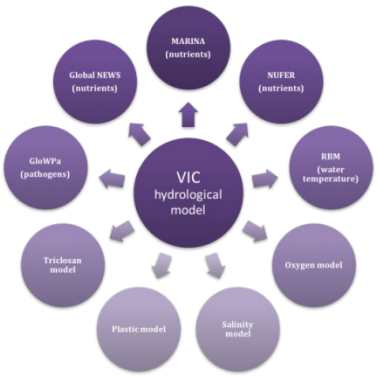


Figure 1. Models co-developed and used for Water Pollution Assessments at WSG

Please visit our website for details on the models (*http://www.wur.nl/en/Expertise-Services/Chair-groups/Environmental-Sciences/Water-Systems-and-Global-Change-Group/research/Water-pollution-assessments-1.htm).*

Cross-cutting Research

Climate-water information services

We develop excellent science-based climate and water services, tailored to the needs and in interaction with users such as farmers, power companies and water managers. Several WSG PhD students contribute to this. Examples of WSG projects in which information services are key include SWICCA, EUPORIAS, WaterApps and EVOCA (see project descriptions on the last pages of this document).

Future water stress

We develop novel tools to identify and evaluate solutions for future water stress. These tools account for the demand for water by society and nature, the availability of water, and the quality of water. We study at the basin, regional, continental and global scales, in spatially explicit models. Examples of such models include VIC (hydrology) and water quality models. Please visit the WSG website for details on these models.

Research Projects

WAGENINGEN
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Greehouse gas fluxes in wet nature

Assessing the impact of rewetting nature on CO_2 uptake and CH_4 emission

dr. Bart Kruijt
2020 - 2023

Research Challenges

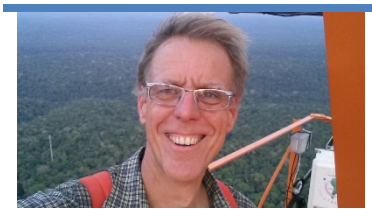
There are many smaller and bigger initiatives to re-wet droughted nature or previous agricultural land, with the main purpose to increase biodiversity. Next to this main objective, there is also an expectation of enhanced CO_2 uptake, and a risk of enhanced CH_4 emissions.
To assess these effects we make direct measurements of the fluxes of these gases, using the Eddy Covariance (EC) technique. The challenge here is, apart from the science, a technical one: can we measure with EC over typically small-scale, heterogeneous terrain, and can we get meaningful results when we measure over periods of only a few weeks.

Methods

Image of EC system in a previous experiment

Expected results and conclusions

We will make alternating measurements in two different ‘ new’ inundated swamp areas near the city of Groningen, using a moveable EC mast. We expect to get an impression on the typical CO_2 and CH_4 exchange for these areas and their response to the weather, time of year, etc. In the end, we aim to quantify the annual budgets for these greenhouse gases and have gained insight on how feasible the methodology used is for the stated objectives.



Contact E-mail: bart.kruijt@wur.nl

GHG-Manage

Managing and reporting of greenhouse gas emissions and carbon sequestration in different landscape mosaics

dr. Bart Kruijt, dr. Ronald Hutjes
2017-2020

Research Challenges

The Paris agreement to significantly reduce GHG emissions emphasised the urgency of accurately quantifying GHG sources and sinks, as well as identifying new mitigation options. Management and land conversion in forests, croplands and grazing lands affect sources and sinks of carbon dioxide, methane and nitrous oxide. Current knowledge on the impact of land-use on GHG exchange refers largely to homo-geneous landscapes. The challenge is to quantify the GHG balance of typical farmed landscapes, comprising a mosaic of different elements, and to provide optimal combinations of land use that have a minimum impact on the GHG budget.

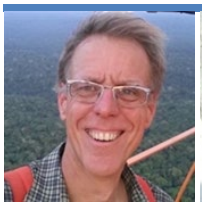
Methods

We will work along the following approaches:

- Develop and use relatively simple measurement devices to monitor C-balance of landscape and farm elements.
- Use airborne observations to assess carbon dioxide exchange in complex, heterogeneous landscapes.
- Develop simple 'discounting rules' allowing the compensate farm emissions by C-sequestration within the same landscape.

Expected results and conclusions

Agricultural landscapes sustain food systems and any GHG mitigation benefits need to be targeted by the food production sector. Many farmers working for a range of multinational companies and organizations use the Cool Farm Tool (CFT), an on-farm GHG emission and mitigation activity calculator. We will improve the CFT, particularly its ability to assess the GHG mitigation of heterogeneous landscapes, in view of currently adopted commitments to combat climate change.



Contact E-mail:
bart.kruijt@wur.nl;
ronald.hutjes@wur.nl

RECSA. Nuffic OKP – Climate Smart agriculture for a resilient Coastal Bangladesh

Project leader: prof. Fulco Ludwig
Project team: Maria del Pozo, Hanne Berghuis.
2019–2021

Project Challenges

This project aims to set up a Climate Smart Agriculture (CSA) institute with Patuakhali Science and Technology University (PSTU) in Bangladesh.

The institute will include the three pillars of CSA: sustainably increasing productivity & incomes, adapting and building resilience to climate change and reducing & removing emissions.

The institute's research will focus on salt intrusion and climate services.

Methods

Capacity building at PSTU through
- Sandwich PhD positions for junior staff
- Post-doc and curriculum development positions for senior staff
- On-site junior staff short courses

Collaborative research by PSTU staff and students with private partners Acacia water, Salt doctors, CIMMYT and Wageningen Research

Joint curriculum development for a PSTU CSA MSc program

Gender balance strategy development

Linking to the local labour market (e.g. including internships or case studies in the curriculum)

Expected results and conclusions

- CSA master program at PSTU
- Strong ties in collaborative research between PSTU, WUR and the private partners
- Papers or joint research grant proposals with Post-doc staff of PSTU
- Knowledge on the effect of climate change on salt intrusion in coastal Bangladesh and the effect of salt intrusion on agricultural practices
- Extended knowledge on the development and implementation of climate services in coastal Bangladesh.

Contact E-mail:
Fulco.Ludwig@wur.nl;
hanne.berghuis @wur.nl

www.csa-bangladesh.org

AMAZON-FACE - impact of future elevated CO2 on the forests of Amazonia

Consortium lead: prof. David Lapola, Universidade de Campinas, SP, Brazil
Wageningen contact: dr. Bart Kruijt, WSG
2015-undefined

Research Challenges

Amazon-FACE is a large and long-term initiative to study the direct impact of future elevated CO2 concentrations on the forests of Amazonia. The overarching question is whether increasing CO2 concentrations will stimulate biomass growth and water use efficiency, or at least increase forest resilience against other detrimental effects of climate change, as a result of its stimulating effects on photosynthesis and water use efficiency.

Methods

The experiment, located in an undisturbed forest reserve north of the city of Manaus (Amazonas state, Brazil), consists of a total of four replicate planned plot pairs of 30 m diameter where CO2 will be artificially elevated by 200 ppm above ambient. The forest, trees, and soils, and their dynamic physiology will be monitored and modelled in detail during the experiment. After installation, fumigation and the experiment is planned to last for about 10 years.

Results and conclusions

The most important scientific challenge is to determine the degree to which the poor soils, particularly extremely low phosphorus, will limit such stimulating effects. Whether or not the forests of Amazonia will suffer under climate change is crucial for the future of Amazonian society, South-American rainfall regimes and global climate.

Contact E-mail: bart.kruijt@wur.nl
www.amazonface.org

https://www.wur.nl/en/project/AMAZON-FACE-impact-of-future-elevated-CO2-on-the-forests-of-Amazonia-1.htm

CLIMAX

Climate Services through knowledge co-production: a Euro - South American initiative for strengthening societal adaptation response to extreme events

dr. Ronald Hutjes, dr. Bart Kruijt
2016-2020

Research Challenges

Climate variability patterns linking Amazonia, with south-eastern South America, influence climate extremes that impact a.o. agricultural production and hydropower. We need to better understand regional climate variability:
1) the combined role of remote and local drivers on South America climate variability
2) the predictability of regional climate patterns
3) extent prediction beyond climate to impacts on agriculture and hydrology
4) how climate data are used by various stakeholders in their socio-cultural contexts;
5) to analyse communication conditions of knowledge co-production

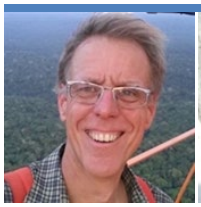
Methods

We will use (combined) hydrology crop models like VIC, LPJmL and WOFOST to assess the predictability of anomalous crop production and hydropower generation, as well as the causes of absence or presence of predictive skill in various parts of the modelling chain.

We will engage in stakeholder interactions in order to tailor forecast products to the needs of potential users, in order to maximise the uptake of climate services in the decision making process.

Expected results and conclusions

Innovative technologies will be co-developed to produce products and tools for the SSA-RCC, agriculture and hydropower sectors. The project will be implemented in the context of the southern South America Regional Climate Centre, and will include actors from the national meteorological services, agriculture and energy stakeholders organizations.



Contact E-mail:
ronald.hutjes@wur.nl;
bart.kruijt@wur.nl

ISIpedia: climate-impact simulations on energy and integrated assessment

Dr Seleshi G. Yalew, Dr. Michelle van Vliet, Prof. Fulco Ludwig, Prof. Detlef van Vuuren

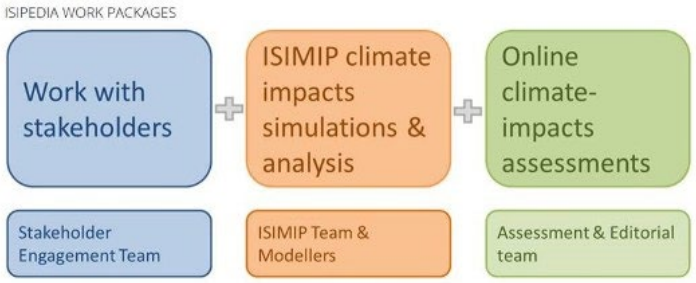
Research Challenges

- Climate change is expected to impact the future of the energy sector and other interacting sectors including land and water.
- The ISIpedia project aims to explore the possible impacts of climate change and provides a hub for tailored information from multi-model climate-impact simulations and assessments in the framework of the ISIMIP initiative.

ISIpedia is financed though the European Research Area for Climate Services (JPI-climate), where NWO financed the Netherlands' contribution.

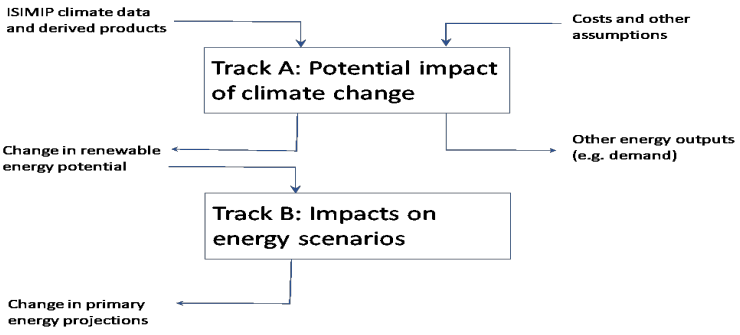
Methods

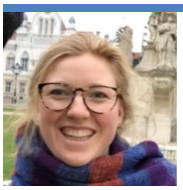
The project involves stakeholders engagement, climate impact modelling and development of online impact assessment tools.



Climate impact on energy

- On energy focused first phase assessment, two tracks of climate impact analysis are followed: climate impact on energy potential (A) and climate impact on energy systems (track B).





E-mail: Fulco.Ludwig@wur.nl & joreen.merks@wur.nl

ISIMIP Inter-Sectoral Impact Model Intercomparison Project

JPI Climate

Climate Smart Agriculture in East Africa

Project leader: Prof. Fulco Ludwig
Researchers: Kitinya Kirina, Emmanual Bizimungu

Research Challenges

The majority of people in East Africa who are dependent on agriculture for their livelihoods will experience an increased vulnerability due to climate variability and change. The Climate Smart Agriculture, East Africa (CSA-EA) programme funded by the Dutch Government will promote climate smart agriculture (CSA) as a way to transform and reorient agricultural systems to the new realities of climate change. The proposed programme will use an inclusive business development approach for CSA in arable farming in Kenya, Tanzania and Uganda. It will thereby contribute to the availability of climate resilient and sustainably produced food for the growing population in East Africa.

Methods

The adoption of climate smart and ecologically sustainable production methods is essential for improving productivity and resilience of the existing food crop production and supply systems. However, until now there is limited data and information available on the impacts of different climate smart agriculture (CSA) interventions on agricultural production, food security and ecological resilience of the farming systems and larges landscapes. To fill this knowledge and data gap we will to assess the impacts of (large scale) implementation of CSAs on the resilience and ecological sustainability at different scales using a combination methods including field measurements and modelling.

Expected results and conclusions

- Climate risk analysis of major food value chains and identification of business opportunities in CSA
- Business case development and matching grant funding to private sector, SMEs, and farmer Cooperatives
- Investment leveraging through facilitating access to finance
- Policy influencing and operationalisation of climate plans
- Feedback of practical applicability of CSA technologies, models and climate science
- Knowledge sharing among countries and network

Contact E-mail:
Fulco.Ludwig@wur.nl

Sustaindus

Targeting a climate change hotspot: science to support the SDGs and sustainable water management in the transboundary Indus river basin

Project leader: Prof. Fulco Ludwig
Researchers: Dr Hester Biemains, Wouter Smollenaars

Research Challenges

The Indus basin is a global climate change hotspot, characterized by a rapidly growing population and strong economic development. This is associated with an exponential increase in water and energy demands. Given the arid climate in the densely populated and heavily irrigated plains and the geopolitical tensions between the riparian states, the road towards achieving the SDGs for water, energy and food is extremely challenging.

Methods

We will develop a range modelling tools to

1. Study a range climate-smart water and food innovations at the field scale including a comprehensive analysis of the physical and economic constraints of upscaling these innovations.
2. Quantify the hydropower potential in the upper Indus under climate changes, and link this with energy demand and potential socio-economic constraints.
3. Assess the future water supply and demand gaps, and the basin-scale potential of adaptation measures
4. quantification of the water-food-energy nexus and the impacts on the SDGs for water, food and energy

Expected results and conclusions

- establish how the water-food-energy supply and demand may evolve in the future and translate global SDGs into quantifiable Indus Basin Development Goals (IDGs),
- develop, test and assess climate-smart technologies to conserve or generate energy and optimize water use and food production and to quantify potential for basin-wide upscaling,
- quantify the synergies and trade-offs between water, food and energy related IDGs,
- develop sustainable pathways consisting of optimal mixes of adaptation measures aimed at reaching the IDGs in a changing climate.

Netherlands Organisation for Scientific Research

Contact E-mail: Fulco.Ludwig@wur.nl

Agmip:

The Agricultural Model Intercomparison and Improvement Project (AgMIP) is a major international collaborative effort to assess the state of global agricultural modeling and to understand climate impacts on the agricultural sector.

Researchers
Iwan Supit & Joost Wolf

Research Challenges

To substantially improve the characterization of world food security as affected by climate variability and change, and to enhance adaptation capacity in both developing and developed countries.

Methods and Goals

1. Intercomparison of multiple crop models to investigate their variability (uncertainty) of response to climate factors of temperature, CO_2, and rainfall, as well as management inputs,
2. Testing multiple crop models against observed response data on temperature, CO_2, water availability, and management inputs,
3. Improving code and relationships of crop models at process-level to give more accurate responses to climatic, management, and genetic factors,
4. Developing methodologies for simulating climate impacts on agriculture for regions with low soil fertility, inputs, and water availability,
5. Applying crop models to evaluate adaptations to minimize impacts and take advantage of climate change scenarios.

Results and conclusions

- The uncertainty of crop yield projections is reduced by improved temperature response (Nature Plants, 2017)
- Similar estimates of temperature impacts on global wheat yield by three independent methods (Nature Climate Change, 2016)
- Rising temperatures reduce global wheat production (Nature Climate Change, 2015)
- Uncertainty in simulating wheat yields under climate change (Nature Climate Change, 2013)

E-mail: iwan.supit@wur.nl

www.agmip.org

Water-SIS. Operational Sectoral Information System for the Water Sector

Project leader: prof. Fulco Ludwig
Researcher: dr. Eveline van der Linden

Research Challenges

This service aims to help water managers to adapt to the impacts of climate change. It offers an interactive web application with refined data, guidance and practical showcases to water managers across Europe, to speed up the workflow in climate-change adaptation by using seasonal forecasts and climate-impact indicators.

Methods

- Develop a high resolution version of the large scale hydrological model VIC so it can be used for an operational service.
- Assess the skill of the model for seasonal forecasts and how it compares to other models used in the operational service.
- Assess the impacts of climate change on water resources in Europe
- Develop a seasonal forecasting systems for the water sector in Europe

Expected results and conclusions

- maps and graphs, showing multi-model ensemble data of water and climate,
- time series to download, with future river flow and water-related indicators,
- high-resolution harmonised datasets for the whole of Europe,
- bias-adjusted data from model ensembles,
- operational seasonal forecast for the water sector in Europe
- real-life examples of decision making in climate adaptation.

Contact E-mail:
Fulco.Ludwig@wur.nl

ULS. Copernicus Climate Change Service (C3S) - User Learning Services (ULS)

Project leader: Prof. Fulco Ludwig
Team: Maria del Pozo, Joreen Merks, Ronald Hutjes and Iwan Supit

Project Challenges

The user learning services aim to create a possibility for professionals to work with climate data. The world of climate information is often a maze to professionals who are not experts in climate change but want to use it in their work. Therefore we develop course material and free blended trainings to teach professionals how to work with the climate data store and, more importantly, how to interpret climate data and use them responsibly in practical sectoral case studies.

Methods

- Free blended trainings in 30 countries across Europe
  - Online course material
  - Two online webinars
  - Face to face training event
  - Hands on case study
- Online learning platform for people who cannot join the blended trainings

Expected results and conclusions

- 30 blended trainings across Europe
- Online learning platform with course material on the Climate Data Store, Climate Data, Seasonal Forecasting and sectoral applications of climate data
- More responsible use of climate data and climate services by the trainees
- Improved capacity to use climate data for Adaptation

Contact E-mail:
maria.delpozogarcia@wur.nl

https://climate.copernicus.eu/user-learning-services

Waterapps: Water information services for sustainable food production in peri-urban delta areas in Ghana & Bangladesh.

Waterapps team: A multidisciplinary team with researchers from WSG and PAP groups, 3 PhD students, in collaboration with various partners from the Dutch private sectors, universities and organisations in Ghana and Bangladesh

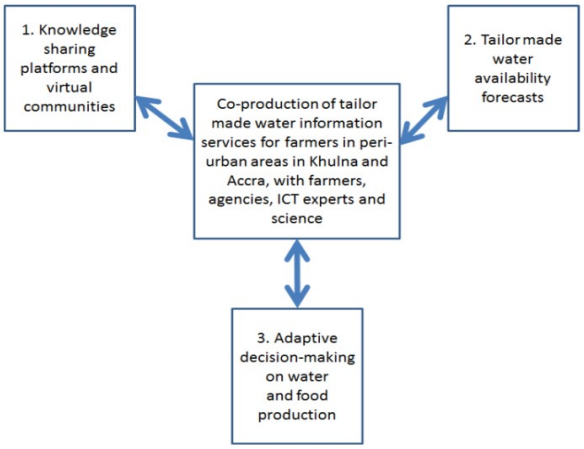
Research Challenges

Due to urbanisation and climate change in deltas, water availability is becoming erratic, affecting farming practices.
Despite increasingly available forecast data and rapid IT developments, famers do not have access to timely & reliable forecast information.
Objective: To develop tailor made water information services with and for farmers in peri-urban areas in Accra, Ghana and Khulna, Bangladesh to improve water and food security.

Methods

This interdisciplinary research will implement three interlinked steps during 2016-2020.
1) Combine mobile information technology (e.g. apps) and insights on knowledge sharing;
2) integrate weather model results with observations of relevant hydro-climatic parameters;
3) Attune knowledge about adaptive decision making and enabling governance structures to local situations. These insights will be used to co-create and test water information services.

Expected results and conclusions



Contacts: erik.vanslobbe@wur.nl or spyros.paparrizos@wur.nl

Website: http://www.waterapps.net

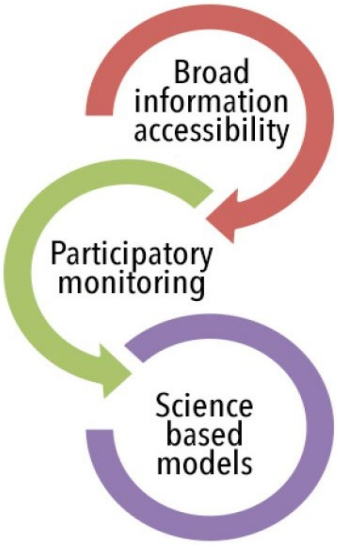
Responsible life-science innovations for development in the digital age: EVOCA

Collaborative interdisciplinary project of WUR and seven partner institutions. WSG leads one of five case studies together with the PAP team, supporting two PhDs. Duration: 2015 - 2020

Research Challenges

EVOCA (Environmental Virtual Observatories For Connective Action) focuses on knowledge sharing platforms and their potential to transform development in five case study areas in rural Africa. Timely information on relevant environmental dynamics holds promise to overcome rural development challenges, for example in agriculture.
Central research question: How can life-science knowledge, digital technologies and responsible innovation concepts be leveraged to address the pressing development challenges in crop, water, health and wildlife management?
WSG and PAP lead a case on climate, water and food; harmonising scientific and indigenous local knowledge systems to provide actionable hydro-climatic information that helps farmers adapt.

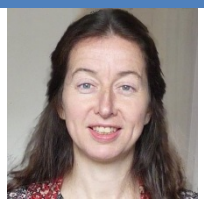
Methods



Expected results and conclusions

- Participatory virtual platforms & digital applications for resource management in African rural communities; Lessons on how digital applications depend on and/or change innovation and research for development (R4D) systems.
- A participatory developed hydro-climatic information service and platform for adaptive decision making in rice farming systems in Ghana.
- 11 PhDs, of which 2 co-supervised by WSG.





Contact E-mail:saskia.werners@wur.nl
Emmanuel.Nyadzi@wur.nl
www.wur.nl/en/project/Responsible-life-science-innovations-for-development-in-the-digital-age-EVOCA.htm

STW-NWO Perspectief Program All-Risk - Implementation of new risk standards in the Dutch flood protection program

Project leader of WSG subproject ***Shared use of flood defences***: dr. ir. Jantsje van Loon-Steensma

Background

The introduction of new flood risk standards in the Netherlands leads to a complex task to assess all flood defences and to reinforce dike sections that do not meet these new standards. There are still many uncertainties (a.o. related to the impact of climate change), which results in a need for more knowledge and innovation. Furthermore, the involvement of a broad range of stakeholders forms a challenge. All-Risk is expected to result in major savings in public expenditures, as future dike reinforcements can be more cost-effective than in the traditional, often conservative, approach.

Project description

Shared use of flood defences

Large stretches of coastal and river dikes are used for multiple co-functions (including nature and landscape values). Some of these functions (e.g., recreation or agricultural use) imply a shared use of the flood defence, and hardly affect the functioning of the flood defence (under proper management and maintenance). This project addresses the question of how to enable multiple uses in the new flood risk approach, while at the same time meeting the reliability requirements.

Research approach

This project will focus on different representative cases (e.g. the Dutch Wadden Sea coast, and in particular on the innovative Parallel defence concept in Delfzijl and on the Wide green dike along the Dollard – eastern Wadden Sea). Attention will be paid to all different functions in the foreshore, the dike zone, as well as at the landward side of the dike zone.

All-Risk participants:
Delft University of Technology (program leader)
Wageningen University
NIOZ & RU Groningen
UNESCO-IHE Delft
University of Twente
Utrecht University
Radboud University Nijmegen

Users:
Companies
Knowledge Institutes and International academic partners
Water boards, RWS, NGO's, Provinces

E -mail: jantsje.vanloon@wur.nl

NWO Living Labs in the Dutch Delta

The Hedwige-Prosper Polder as a future-oriented experiment in managed realignment: integrating saltmarshes in water safety

Project leader of WSG subproject ***Nature-based design and maintenance of dikes***: dr. ir. Jantsje van Loon-Steensma

Background

In the coming four years, the Hedwige-Prosperpolder in the Schelde estuary will be reopened for nature restoration. This creates opportunities, within a binational Dutch-Belgian consortium, to experiment with the existing dike and to perform targeted dike breach experiments and breach monitoring. In this project will be investigated technically how marshes restrict dike breaching, how realignment can foster marsh development and how dikes should be designed in this context. Furthermore, there will be monitored whether these new insights can reconnect people with the changed landscape.

Project description

Nature-based design and maintenance of dikes

The objective of this project is to develop innovative nature-based design and maintenance of dikes, providing ecological connectivity between dike and foreland, maintaining dike integrity and optimizing ecosystem services, by:

- Experimental study on the short-term impact of nature-based adaptations on the grass-covered seaward face
- Experimental study on the short-term impact of different regimes for the removal of debris from the adjacent salt-marsh
- Assessing the impact on safety by modelling
- Development of guidance on nature-based adaptation and maintenance of dikes

Project Partnes:
Delft University of Technology (program leader)
NIOZ
Wageningen University
HZ University of Applied Science

Users:
STOWA, Province of Zeeland, Ecoshape, Rijkswaterstaat , Water board Scheldestromen, WEnR, HKV, SVASEK

E-mail: jantsje.vanloon@wur.nl

CRUCIAL
Service for Global Agriculture Indicators in Climate Change Adaptation

Researcher
Iwan Supit

Supervisor
Dr. Ronald Hutjes

Research Challenges

Weather and climate data are essential in managing various aspects of food security at all spatial and temporal scales. Near-real-time data will help make day-to-day farming decisions. Seasonal forecasts support more systemic adaptive decisions, such as cultivar choices, commodity trading and food emergency preparedness. Past and future climate normals, documenting climate change, support transformational decisions, such as breeding new crop varieties and relocation of production areas.

Methods

In this Copernicus Climate Change Service (C3S) project we co-design climate services together with three user -champions, globally active in the agricultural sector that represent international crop research, agricultural policy development and commercial agricultural consultancy.
We provide crop specific indicators, in addition to generic, agricultural relevant climate indicators. We provide changes in management relevant crop development, water use and harvest index for historic present and future climate.

Main results and conclusions

The service delivers 4 types of data products, plus tools to aggregate all statistics to actual crop areas and crop calendars.

Agro-climatic indicators	Provision and visualisation of agriculturally relevant climate indicators and statistics, if needed tailored using crop-specific parameters
Climate forcing data for crop models	Provision of raw climate data in easily accessible and usable formats for downstream analysis and forcing of agricultural impact models, both gridded and location specific
Climate enhanced EO based indicators	Provision of merged Earth Observation–climate data indicators of crop productivity, harvest indices and crop water use
Water based indicators	Provision of agricultural water resource indicators, such as those for soil moisture, surface- and groundwater availability, river discharge and reservoir status

E-mail: ronald.hutjes@wur.nl
See: https://climate.copernicus.eu/global-agriculture-project

Evidence-Based Guiding Principles for Developing Adaptation Pathways to Infrom Adaptation Policy and Practice in Africa and Asia

CARIAA Adaptation Pathways team: this project brings together a dedicated team of researchers and strategic partners from four consortia supported by the Collaborative Adaptation Research Initiative in Africa and Asia (CARIAA) Programme (cariaa.net).

Research Challenges

In the context of climate change adaptation, adaptation pathways are proposed as a promising decision-focused approach.

Adaptation pathways sequence measures over time and allow for progressive implementation depending on how the future unfolds. Potentials are the ability to account for uncertainty, to identify 'no or low regrets' interventions, and to avoid lock-in, threshold effects and mal-adaption.

The CARIAA consortia, as well as other research groups, are experimenting with pathway development. As yet, there has been no systematic analysis of different approaches to adaptation pathway development.

Methods

The project will first design a framework for structured synthesis and learning about adaptation pathway development.

Second, the project will develop adaptation pathways in selected cases in Africa and Asia.

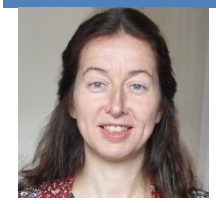
Third, a Community of Practice will be initiated by project partners and strategic partners.

Third, synthesis will yield lessons across consortia and guiding principles.

Expected results and outcomes

This project will deliver:

- Lessons on the strength and weaknesses of different ways to develop adaptation pathways
- Evidence-based Guiding Principles for adaptation pathway development to inform decision-making for adaptation policy and practice
- Community of Practice
- Pocket guide and publication with guiding principles to make use of the strength of adaptation pathways development for the needs of policy and practice



Contact: Saskia Werners
(saskia.werners@wur.nl)

and

KLIMAP

dr. Erik van Slobbe

- 2017-2020: coordinator the 'Boeiende Beekdalen' – 'fascinating stream valleys' – theme – Lumbricus
- 2020-2023: contributor (with Bregje van der Bolt) Adaptation Pathways theme - KLIMAP

Research Challenges

Dutch water authorities are aware that water catchments currently are not sufficiently resilient to cope with expected changes in extreme weather events. Water systems are characterized by dense networks of hard water infrastructure. These infrastructures are not flexible and cause vulnerabilities. Additionally authorities have to invest in ecological restoration of water systems. Therefore, nature based approaches, like Building with Nature, and new, flexible planning methods are needed.

Methods

Both projects are transdisciplinary innovation program, involving governments, research institutes, universities and entrepreneurs. Conducting experiments in living labs. Researchers are involved in co-designing water systems, monitoring and producing adaptation pathway planning.

Expected results and conclusions

Monitoring of building with nature projects in the Netherlands together with theory building on nature based designs for small rivers and adaptation pathway planning.

Contact E-mail: erik.vanslobbe@wur.nl and bregje.vanderbolt@wur.nl

WAGRINNOVA

Co-innovations across scales to enhance sustainable intensification, resilience, and food and nutritional security in water-managed agricultural systems in West Africa.

dr. Erik van Slobbe
2018-2021

Research Challenges

The development of irrigated and improved lowland agriculture in Western Africa has not resulted in a significant increase in food security or in a motor for economic growth, in spite of its large potential and the great benefits observed in other regions of the world like Spain. WAGRINNOVA aims at understanding why irrigated agriculture has not resulted in the expected impact, and at setting the basis for changing this.

Methods

Participatory tool development in the field of soil moisture and water availability forecasts in rain fed rice cultivation in Northern Ghana.
Use of ICT for interactions between experts and farmers and upscale to other areas in Western Africa.

Expected results and conclusions

WUR will produce two results:

1. Develop a rice farmer's decision support system based on weather forecasting.
2. Support the Northern Ghana irrigation and low land agriculture hubs.

Contact E-mail: erik.vanslobbe@wur.nl

SURE+: Sustainable Resource Management for Adequate and Safe Food Provision in China

Subproject 2 and B: 2017-2021
Subproject leader: Prof. Carolien Kroeze
PhD students: Ang Li and Jing Yang
Postdocs: Dr Maryna Strokal, Dr Annette Janssen and Mengru Wang

Research Challenges

- Inadequate food production with environmental impacts;
- The SURE+ project aims at interdisciplinary research on the land, water and food nexus in China (Fig. 1).

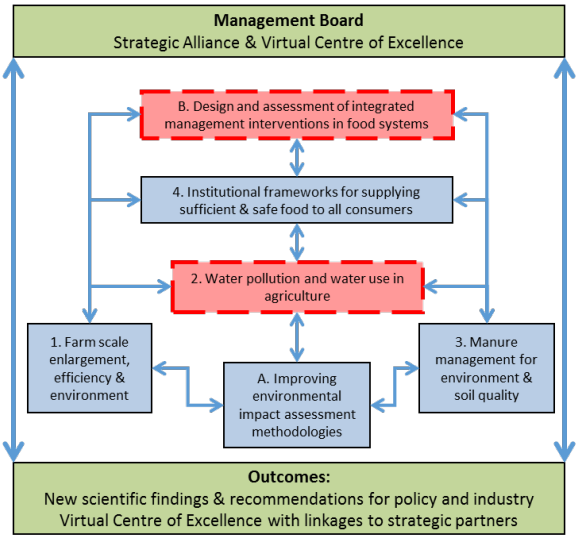


Fig. 1 Relationships between the sub-projects of SURE+. Red indicates the WSG subprojects.

Methods

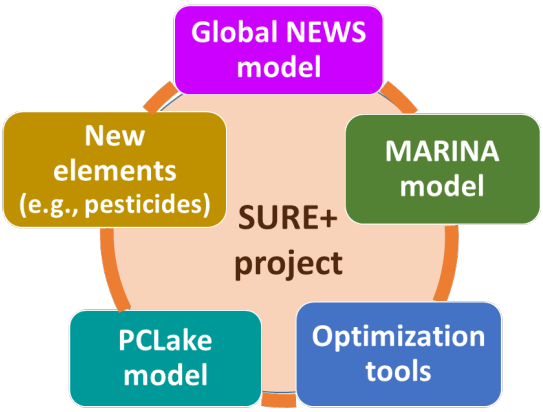
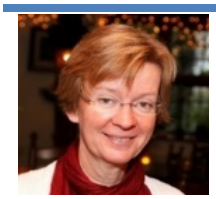


Fig. 2 Integration of existing models and development of new models

- Innovative methodologies (e.g., Fig. 2) that can be applied for examining similar problems in other parts of the world

Expected results

Recommendations for adequate and safe food provision based on sustainable resource management.



Contact:
Prof. Carolien Kroeze
Carolien.Kroeze@wur.nl

FertiCycle ITN project: Modelling the effects of bio-based fertiliser use on surface water pollution at catchment & EU scales (ESR13)

Period: 2020-2024

WSG Researchers
Prof. Carolien Kroeze
Dr Maryna Strokal

Research Challenges

The objectives of this research are (Figure 1):

i) parametrising and linking the Miterra-Europe and the MARINA models,

ii) estimate the effects of bio-based fertilisers on water and environmental pollution at catchment, and

iii) European scales.

The linked model system will be used to assess the effects and interactions of policies and measures in agriculture, for a number of scenarios for the future (up to 2050).

The WSG project is in collaboration with University Gent (UGent) in Belgium (https://www.ugent.be/)

Full FertiCycle project:

https://plen.ku.dk/english/research/plant_soil/sf/research-projects/ferticycle/

Methods

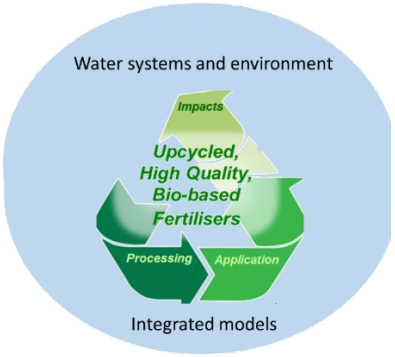


Figure 1. Effects of bio-based fertilizers on water systems and environment. Integrated models such as a Model to Assess River Inputs of pollutAnts to seAs (MARINA).

Expected results

(1) New modelling system;
(2) Effects of bio-based fertilizers on water and environmental pollution at catchment scale;
(3) Effects of bio-based fertilizers on water and environmental pollution at European scale;
(4) Scenario analyses for effects of policies and measures in agriculture on water and environmental pollution in the future.

Contact E-mail:
maryna.strokal@wur.nl
carolien.kroeze@wur.nl


MARINA: Model to Assess River Inputs of Nutrients to seAs.

MARINA Team: A multidisciplinary team with researchers from Wageningen and China. In WSG several PhD students work with the MARINA Model.

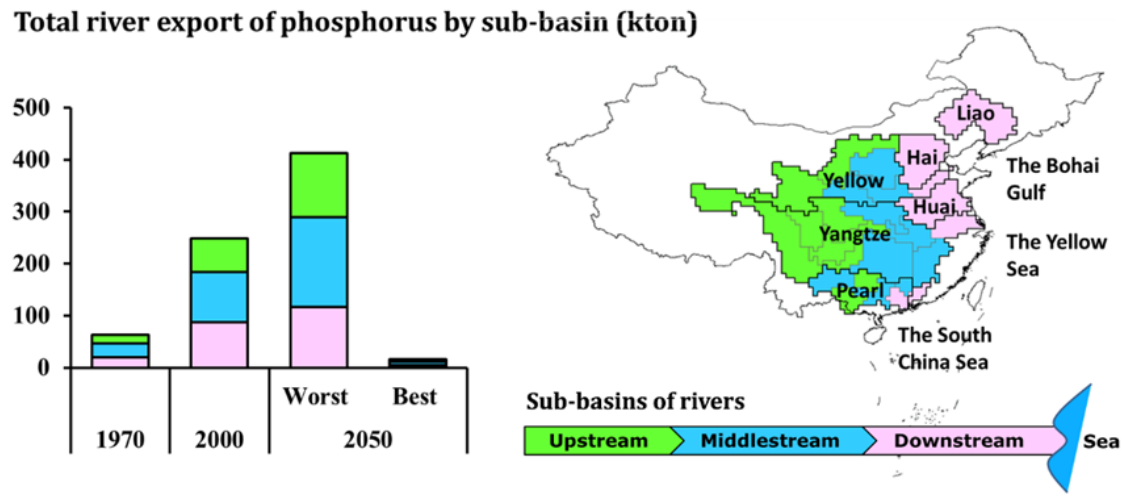
Research Challenges

Nutrient pollution is a problem in many Chinese rivers. As in many other world regions, the most important causes include agriculture, urban waste, and industries. In China, animal production is a relatively large source of nutrients in rivers. This is a result of the fast industrialization of the animal production sector, and low nutrient use efficiency of food production.

Methods

MARINA is a Model to Assess River Inputs of Nutrients to seAs. It is a downscaled version of the Global NEWS (Nutrient Export from WaterSheds) model for China, but with better modelling of animal manure and human waste as well as with updated information for reservoirs. The model runs at the sub-basin scale for six main rivers in China that drain into the Bohai Gulf, Yellow Sea and South China Sea (see figure below).

Example of model output



Contact: Dr Maryna Strokal (maryna.strokal@wur.nl)

Global NEWS: Nutrient Export from WaterSheds

Global NEWS Team: A multidisciplinary team with researchers from many research institutes. In WSG several PhD students work with Global NEWS related models. Reference: Seitzinger et al (2010) GBC. doi:10.1029/2009GB003587

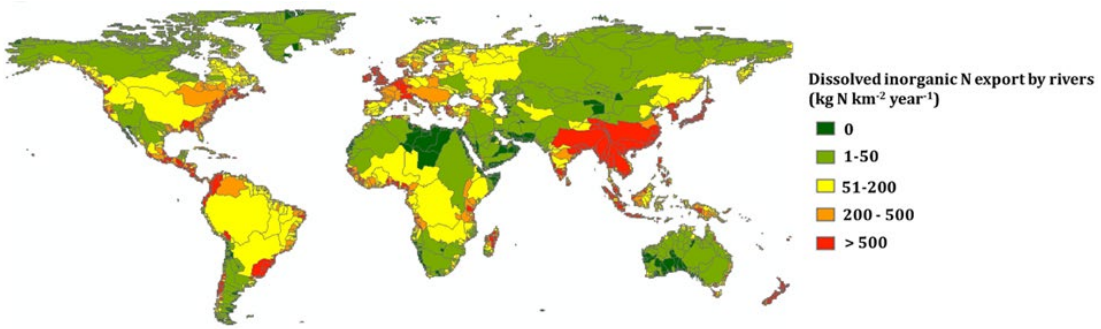
Research Challenges

Many rivers are polluted with nutrients. This is a worldwide problem. Excessive nutrient loads may result in eutrophication. The associated environmental problems include ground water pollution with nitrate, eutrophication and harmful algal blooms.
The most important causes of nutrient pollution are human activities on land: agriculture, urban waste, and industries are important sources of nutrients in rivers.

Methods

Global NEWS is a Nutrient Export from WaterSheds model. The model quantifies annual river export of nitrogen, phosphorus, carbon and silica in dissolved inorganic, organic and particulate forms. The model quantifies the source attribution and the Indicator for Coastal Eutrophication Potential (ICEP). The model distinguishes between point and diffuse sources of nutrients in rivers. Point sources include sewage effluents from wastewater treatment plants. Diffuse sources include typically leaching/runoff of nutrients to rivers from fertilized and non-fertilized soils.

Example of model output



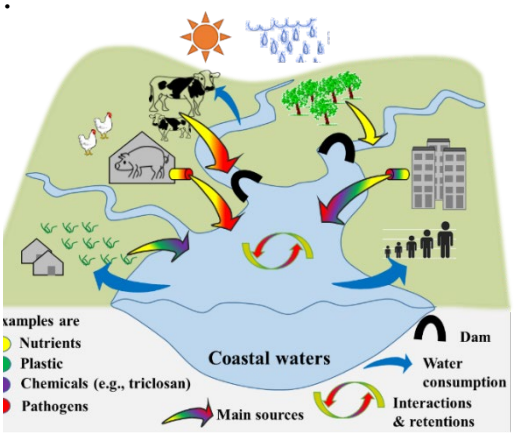
Contacts: Prof. Carolien Kroeze
(carolien.kroeze@wur.nl)

Multi-pollutant modelling of water quality

Prof. Carolien Kroeze
Dr Maryna Strokal
Dr Nynke Hofstra
Wietse Franssen
Water Systems and Global Change

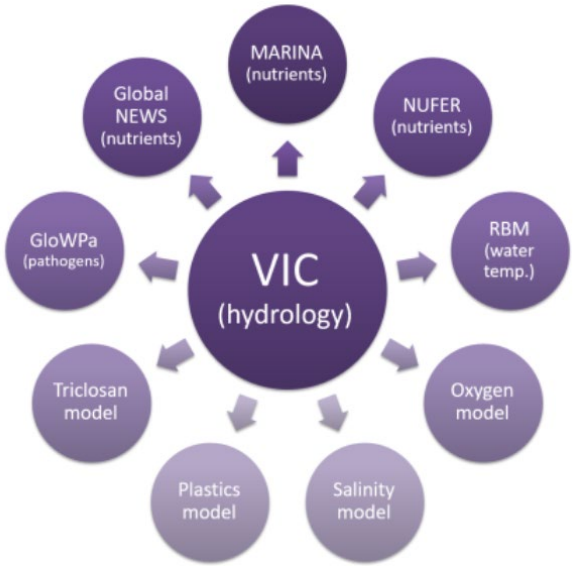
Research Challenges

- More than one pollutant in rivers
- Common sources
- Multiple impacts



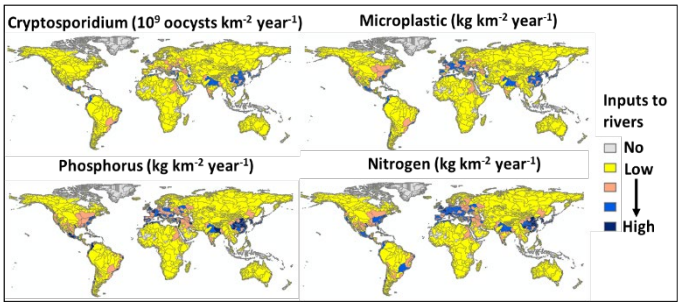
Simplified illustration of multi-pollutant problems in river systems.

Methods



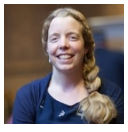
Modelling multiple pollutants in water systems worldwide by using existing modelling approaches for individual pollutants.

Example of model output



Inputs of selected multiple pollutants to rivers from sewage systems in 2010 (Strokal et al., 2019)






Contact E-mail:
maryna.strokal@wur.nl
carolien.kroeze@wur.nl
nynke.hofstra@wur.nl
wietse.franssen@wur.nl

Booming or blooming? The future of lakes in a changing world

dr. Annette B.G. Janssen
(2020-2024)

Research Challenges

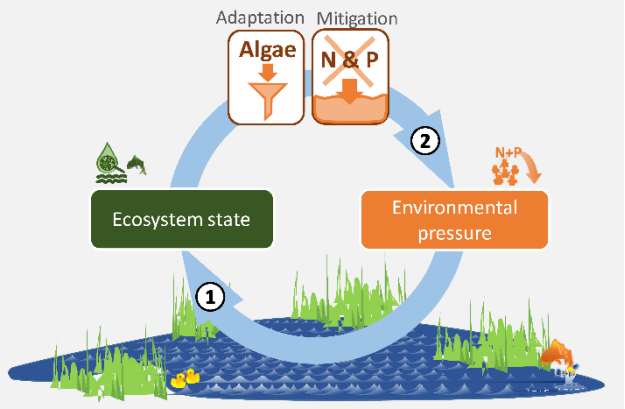
Algal blooms turn lakes into toxic soups. Why are we unable to prevent them? In this Veni-project the interaction between society and environment is studied to find new solutions to prevent algal blooms. These solutions will help us to restore our lakes back to a healthy environment.

Objective: To find optimal solutions to algal blooms in lakes by studying the feedback loop between environmental pressure and ecosystem state.

Methods

A novel model will be developed to study the feedback loop between environmental pressure from nutrient loading and the ecosystem state (turbid or clear). In this new model, lakes are simulated as part of a river network to account for the interaction between lakes through river networks.

Expected results and conclusions



In three steps, ecology, economy and social sciences are combined within one feedbackloop:
1) study the effect of environmental pressure on the lake ecosystem state using a network of lakes.
2) study the effect of lake ecosystem state on the environmental pressure using economic optimization.
3) combine steps 1 and 2 to identify optimal solutions for nutrient reductions under different adaptation and mitigation strategies.

Contact: annette.janssen@wur.nl

VENI project:

Clean water for all: optimal solutions for reducing multiple pollutants in rivers worldwide

Time: 2019-2023
Project leader: dr. Maryna Strokal

Research Challenges

Methods

Solving river pollution is challenging because causes of pollutants and their interactions in the environment are not well understood. This project identifies optimal solutions for river pollution that account for such interactions. For this, a multi-pollutant model with spatial optimisation is developed (Figure 1).

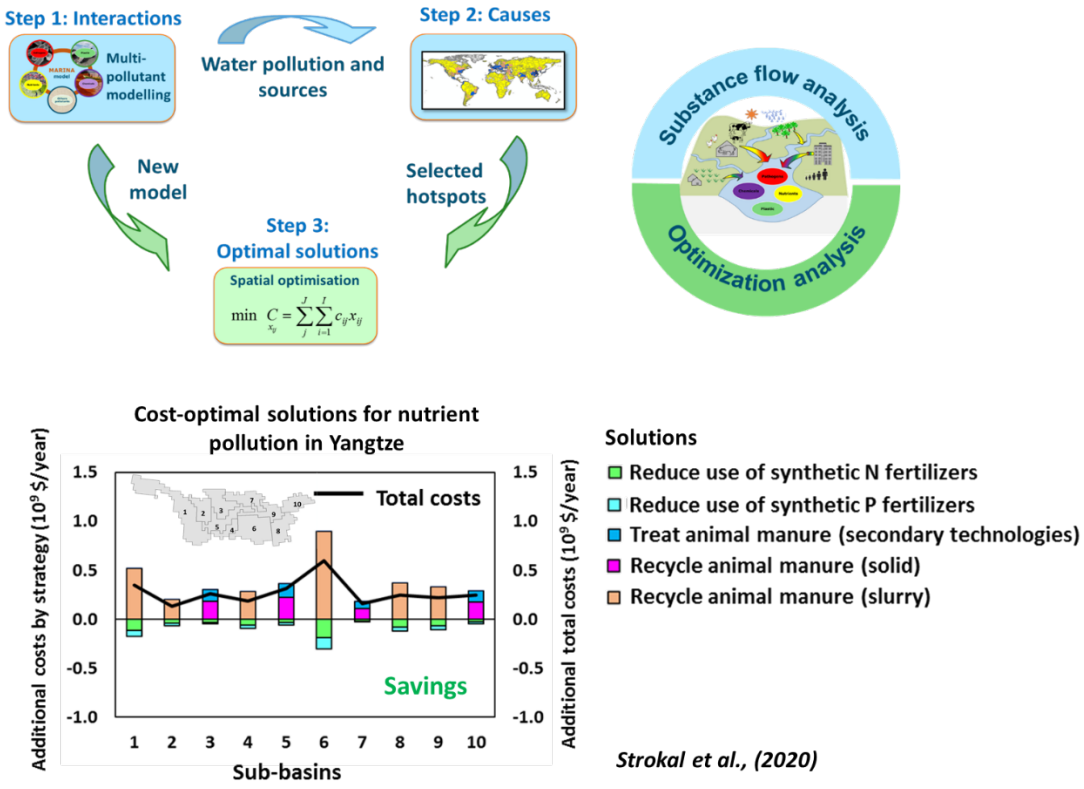


Figure 1. Research strategy to identify optimal sets of mitigation options to reduce future river export of multiple pollutants in selected hotspots by sub-basin, sector (option) and year.

Contact E-mail:
maryna.strokal@wur.nl

Knowledge to practice (K2P): Innovating evidence-based safe sanitation decision support tools

Researchers
dr. Nynke Hofstra
Daniel Okaali, MSc
2018-2021

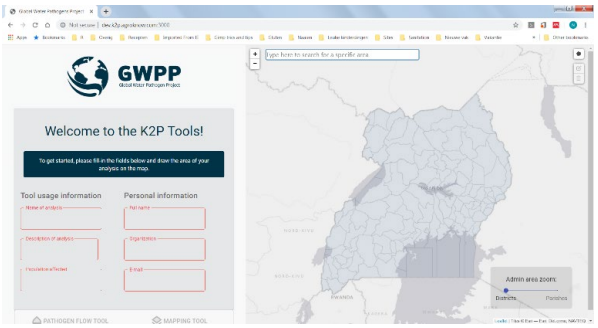
Objective

The goal of the K2P project is to support water and sanitation planners with user friendly tools to help improve data accessibility, and knowledge translation around pathogens in excreta and sewage. This project leverages the open access knowledge resources generated by the Global Water Pathogen Project (GWPP) (www.globalpathogens.org).

Methods

Developing the Global Waterborne Pathogen (GloWPa) model into a model for pathogen emissions and concentrations in rivers that is flexible for:

- selected pathogens in rivers
- spatial scale and resolution
- area
- scenarios



Expected outcomes

Primary outcome is to have improved scientific tools and data that WASH professionals will use to apply an evidence-based approach to water and sanitation safety planning. Uganda is the first implementation country in the development of these Information Technology (IT) tools. Some intermediate outcomes for the project include:

- An established coalition of national and global stakeholders who are involved in the work to plan, implement, monitor and improve progress toward the water and sanitation targets for SDG 6.
- Improved analytical tools to access and interpret scientific data on the efficacy of sanitation services, link these data with other national databases, and derive appropriate statistics and modelling results that can be used for evidence-based water and sanitation safety planning and effort prioritization.
- Increased local capacity for our partners in country.

E-mail: nynke.hofstra@wur.nl

UNCHAIN – Unpacking climate impact CHAINs.
A new generation of action- and user-oriented climate change risk assessments

Prof. Fulco Ludwig;
Dr. Emmanuel Nyadzi
2019 –2023

Research Challenges

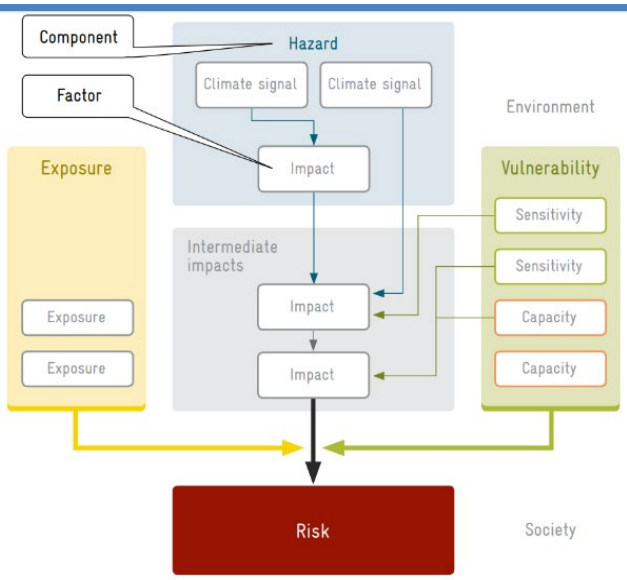
Case 1: *Climate change impacts on financial investment portfolios*

1. How to determine the risk of climate change on financial portfolios at different scales
2. How to integrate climate and financial risks including future socio-economic change for an informed financial investment decisions.

Case 2: *Risks and impacts of climate change on railway infrastructure:*

1. How will excessive heat and changes in future Storms affect the railway sector
2. At what timescales should climate risk be assessed

Methods



Structure and element of the impact chain model (Zebisch et al. 2017

Expected results and conclusions

1. To produce a climate change risk that covers possible need for short term adjustment and long-term efforts of societal transformation
2. To refine a structured method of co-production of knowledge into the impact modelling
3. To develop and test an applicable framework for analysing how societal change can affect local climate change vulnerabilities
4. To develop and test a standardized analytical framework for addressing uncertainties involved in local decision-making on climate change adaptation.
5. To include the trans-national impacts of climate change and to link mitigation and adaptation in climate risk and vulnerability assessments

Contact E-mail:
Fulco.Ludwig@wur.nl
emmanuel.nyadzi@wur.nl

PhD research projects

WAGENINGEN
UNIVERSITY & RESEARCH

Towards a probabilistic crop yield forecasts using dynamic seasonal climate forecasts and advanced Crop modelling over East Africa

Researcher
Geoffrey Ogutu
(2013 – 2017)

Supervisors
Dr Ronald Hutjes
Dr Philip Omondi (ICPAC)
Prof. Rik Leemans

Research Challenges

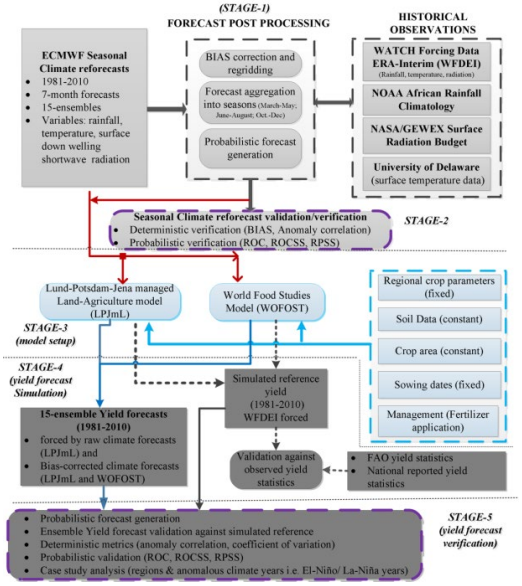
Problem definition:

- Use of dynamical seasonal climate forecasts for prediction of impacts on crop production;
- Lack of detailed information for users at different scales;
- Lack of detailed regional impact model.

The main objective:

- to improve model prediction of impacts of future seasonal climate conditions on agriculture at seasonal time scales

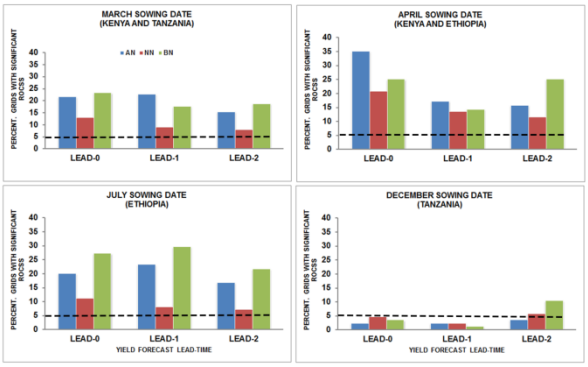
Methods



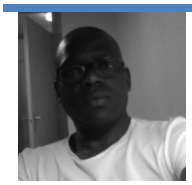
Main results and conclusions

Different cropping seasons from climate and crop production forecasts (1981-2010):

- Prediction in meteorology: better for temperature than for rain and radiation;
- Fair prediction for maize yields a few months (at least 2-months) **before** start of season (e.g., Fig.1);
- Prediction varies with forecast lead time and region.

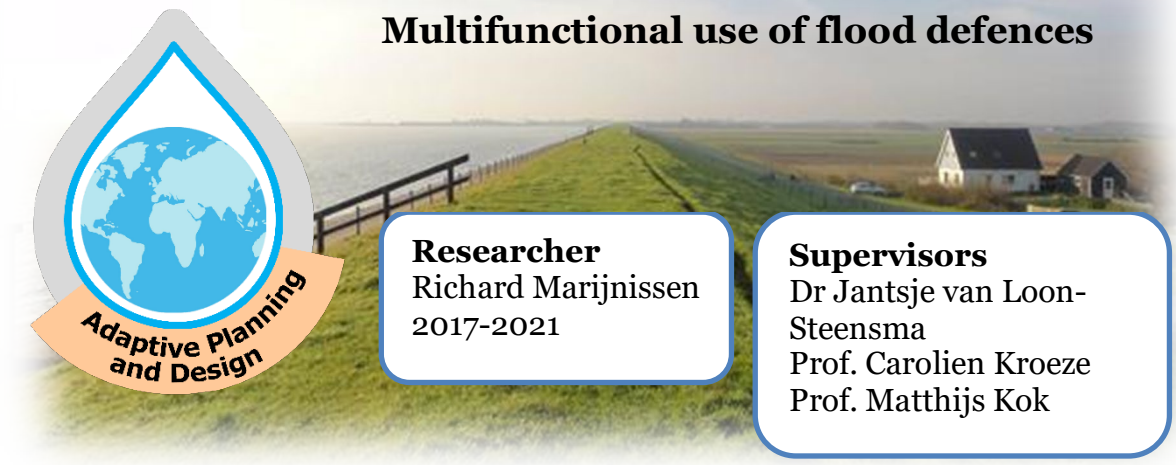


Percentage grid cells of good & significant prediction shown as a function of planting dates. METRIC: - Relative operating curve skill score (ROCSS). Dashed line show score obtainable by chance at 95% significance level.



E-mail: geoffrey.ogutu@wur.nl

Multifunctional use of flood defences



Researcher
Richard Marijnissen
2017-2021

Supervisors
Dr Jantsje van Loon-Steensma
Prof. Carolien Kroeze
Prof. Matthijs Kok

Background image: https://beeldbank.rws.nl, Rijkswaterstaat

Research Challenges

Flood defences have the potential to be integrated with many other function (e.g. nature, recreation, transport, housing etc.). Adding some functions can increase the risk of flooding of a primary flood defence whereas other functions (e.g. natural foreshores) can provide synergies to decrease flood risk. The objective is to gain more insight in the effects of the multifunctional use of flood defences on flood risk using the new probabilistic risk standards recently adopted in the Netherlands

Methods

- Defining limit states for additional functions on dikes
- Calculating how multifunctional dike elements affect the probability of failure
- Calculating the probability a multifunctional dike cannot fulfil its secondary functions
- Apply these insights to case studies of multifunctional dikes in the north of the Netherlands

Results and conclusions

The means to objectively compare new dike concepts is lacking within the new risk standards. As a result, innovative multifunctional options are only occasionally implemented. This research will bridge this gap to allow for implementation of suitable multifunctional dike concepts by contributing to a comparative framework for multifunctional dikes.

E-mail: richard.marijnissen@wur.nl

The role of climate research in Dutch Water Management

Researcher
Jeroen Veraart
(2007-2018)

Supervisors
Prof. Pavel Kabat
Dr Erik van Slobbe

Research Challenges

The objective is to explore how scientific knowledge about climate change is used and how uncertainties are typified between scientists, policy makers and water users in Dutch Water management in the period 2000-2014.

This research question has been studied at national (Delta programme), regional (Southwest Netherlands) and at farm level (3 pilots) and can be qualified as a nested case study (Flyvbjerg, 2006) and within this PhD thesis presented as a temporal analogue (2000-2014).

Methods

Results and conclusions

The usability of climate research for Dutch water management could be further enhanced by working in interdisciplinary teams during policy formulation in which fact checkers, knowledge de-constructivists and knowledge constructors are equally represented. Many knowledge qualification methods and uncertainty assessment frameworks are all useful and valuable. We recommend defining relevant categories of uncertainty in a collaborative way between climate research and knowledge users in water management, before commissioning research, prioritizing research themes or starting a policy process.

Veraart J, Nieuwaal K, Driessen PJ, Kabat P (2014) From climate research to climate compatible development: experiences and progress in the Netherlands. Regional Environmental Change 14 (3):851-863. doi:10.1007/s10113-013-0567-7. ©Springer, available online http://link.springer.com/article/10.1007/s10113-013-0567-7

Veraart, J. A., R. van Duinen, and J. Vreke. 2017. Evaluation of Socio-Economic Factors that Determine Adoption of Climate Compatible Freshwater Supply Measures at Farm Level: a Case Study in the Southwest Netherlands. Water Resour Manag 31: 587-608.

E-mail: jeroen.veraart@wur.nl

Developing Climate Adaptation Services: what works when and why?

Researcher
Eva Boon
2019 - 2022

Supervisors
Prof. dr. Fulco Ludwig
Dr. Robbert Biesbroek
Dr. Hasse Goosen

Research Challenges

Adapting to climate change requires context-specific and actionable information. Governments and businesses are therefore increasingly investing in tailored climate information products and support. The performance of the 'climate services for adaptation', however, is poorly understood and hardly evaluated. How do we know if these climate services actually support societal actors to plan for climate change adaptation? What determines the success of climate services? And can success be 'managed'? This research examines what constitutes the success of climate services, and which strategies lead to success under what conditions.

Climate Services for Adaptation are defined as:

The transformation of climate-related data – together with other relevant information – into customized products that may be of use for the society at large to plan for climate change adaptation

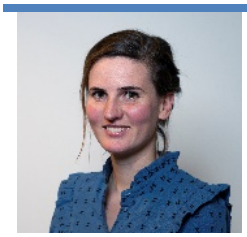
Examples are climate change projections, impact studies, risk and vulnerability assessments, effectiveness studies of adaptation options, and learning from best practices. They can vary from detailed and technical information products to simple visuals and interactive workshops.

Methods

This research aims to *understand and explain how successful climate services can be produced and evaluated*. To this purpose a systematic literature review and expert elicitation study are performed to define success and identify critical factors that contribute to it. These studies result in a framework that will be tested by using a fuzzy-set-QCA to explore the configurational nature of factors leading to success in ~30 cases (e.g. what practices work in what context?). Finally, through action research, the identified success conditions are implemented in three climate service projects to explore the practical usability of the factors as design principles to steer climate service success.

Results and conclusions

The research will provide a framework for evaluating the performance of climate services and will suggest strategies to improve their performance.



E-mail:

eva.boon@wur.nl
eva@climateadaptationservices.com

Assessing spatial and temporal impact and adaptation strategies of climate and land use changes on water supply and demand in the Mara River Basin, Kenya

Researcher
John R. Omare
(2015-2019)

Supervisors
Prof. Petra Hellegers
Prof. Fulco Ludwig
Dr Fidelis Kilonzo

Research Challenges

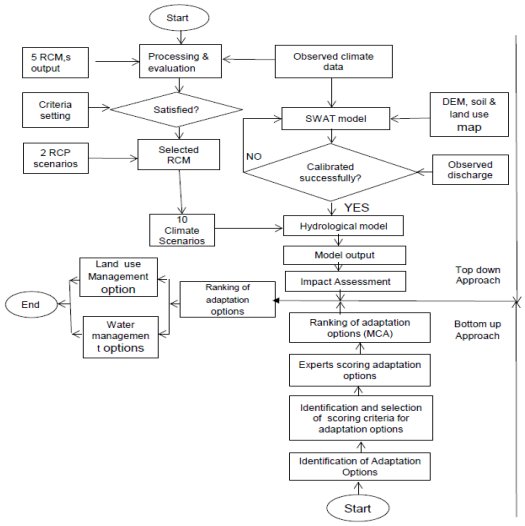
Problem definition;

- The Mara River Basin (MRB) is experiencing an increasing gap between water supply and demand.
- Limited knowledge exists on the combined spatial and temporal effect of climate and land use change on water supply and demand in MRB.

The main objective;

- to assess climate and land use change impacts and adaptation strategies to water supply and demand in MRB.

Methods



Integration of SWAT model and Multi criteria analysis to identify water management options.

Expected results and conclusions

- A review of current water supply and demand gaps in the Mara River Basin.
- Analysis of the impacts of climate change on water demand and supply in the Mara River Basin.

E-mail: john.omare@wur.nl

Developing integrated adaptation options to achieve SDG 2 & 6 in the Indus basin.

Researcher
Wouter Smolenaars
2019-2023

Supervisors
Prof. Dr. Fulco Ludwig
Dr. Hester Biemans

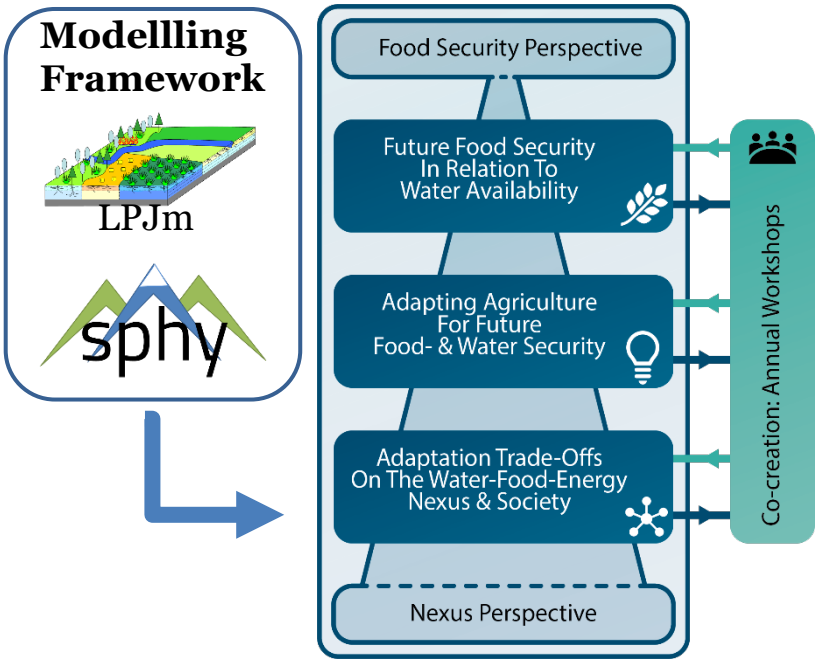
Research Challenges

1. Quantitative insight into the combined effect of climatic- and socio-economic change on food security in the Indus basin is lacking.

2. The potential of upscaling climate-smart innovations to jointly achieve food- and water security is currently unclear;

3. The impact of large scale adaptation of agriculture in the Indus basin on water-food-energy nexus is not well understood;

Methods



Expected results and conclusions

1. Basin-scale, stakeholder supported insight into future water- & food security;
2. Adaptation pathways that balance the pursuit of water- and food security on the basin-scale;
3. An integrated assessment of the trade-offs and synergies of adaptation measures from a nexus-perspective.

E-mail: wouter.smolenaars@wur.nl
woutsmolenaars@hotmail.com

Tailor-made Water Information Services for Sustainable Food Production in Peri-Urban Delta in Bangladesh

Researcher
Uthpal Kumar
(2017-2020)

Supervisors
Prof. Fulco Ludwig
Dr Saskia Werners
Dr Long Hoang

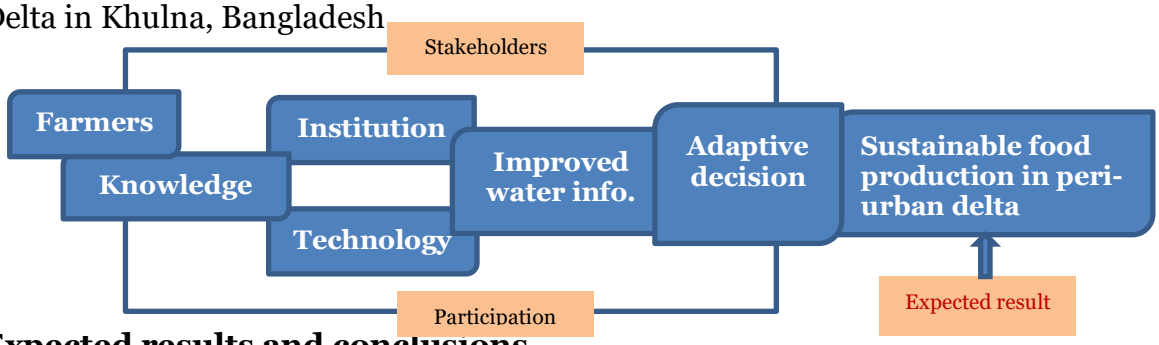
Research Challenges

Problem statement: Water for agriculture is vital to safeguard sustainable food production. Due to urbanization and climate change, water availability (too much, too little and too early or late) is becoming erratic and farmers cannot rely on their existing knowledge to plan farming practices.

Key objective: This research aims to develop tailor made water information services with and for farmers in the peri-urban Ganges Delta in Khulna, Bangladesh

Methods

An integrated socio-technical method will be applied for this research by 1) combining mobile information technology like apps; 2) integrating weather model results with observation of groundwater trends and river flows; and 3) adjusting knowledge about adaptive decision making and enabling governance structures to local situations.



Expected results and conclusions

Improved understanding of

1) Co-production of water information system with and for farmers.
2) Peri-urban farmers empowerment and livelihoods in Bangladesh Delta.
3) Capacity of small/medium farmers for sustainable food production in Bangladesh Delta.

E-mail: uthpal.kumar@wur.nl

Hydrological Response of the High-Altitude Indus Basin to Climate Change

Researcher
Zakir Hussain Dahri
(2012 – 2017)

Supervisors
Prof. Pavel Kabat
Prof. Eddy Moors
Prof. Fulco Ludwig

Research Challenges

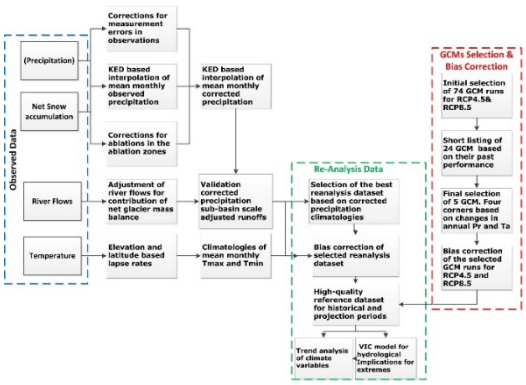
Problem definition:

- Largely an underexplored basin due to:
  - inadequate climate monitoring network
  - measurement errors in observed data
- Substantial errors in global/regional scale gridded climate datasets, particularly in precipitation products
- Large uncertainty of hydro-climatic predictability

Main objective:

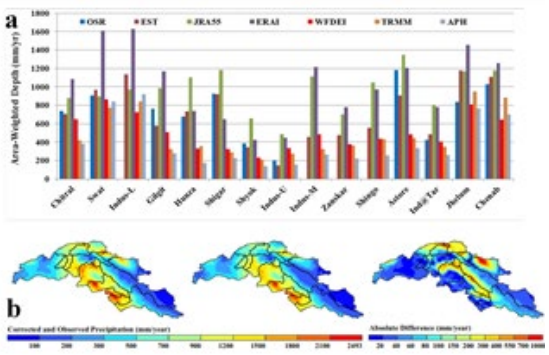
- Analyse climate change and its hydrological implications

Methods



Results and conclusions

- Gridded precipitation products often underestimate precipitation in the study area, but reanalysis products are relatively better.
- The corrections significantly improved the quantitative and spatiotemporal distribution of precipitation
- The contribution of net glacier mass balance to river flows is only marginal.
- The corrected Pr and T climatologies are used to develop a reference dataset which will be used to analyse climate change and its hydrological implications for the future.



(a) Mean annual observed specific runoff and precipitation from different gridded precipitation products, b) spatial distribution of corrected and actually observed precipitation and absolute bias between them.

E-mail: zakirdahri@wur.nl

Impact Assessment of future climate change on the streamflow of the lower Ganges basin

Researcher
Kazi Saidur Rahman

Supervisors
Prof. Fulco Ludwig

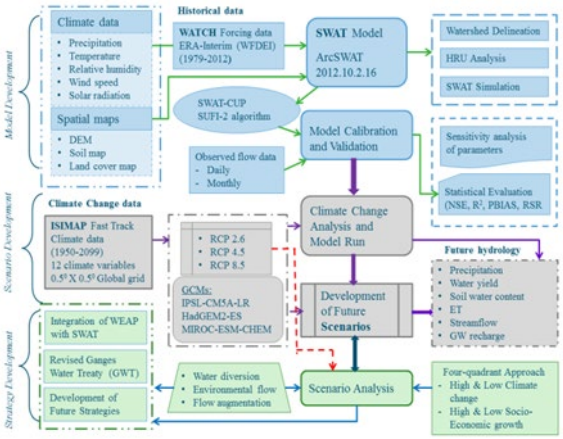
Research Challenges

Problem Statement:

- Vulnerable to climate change and upstream water diversion.
- Wide seasonal variations in precipitation.
- Reduced flow in the dry season.

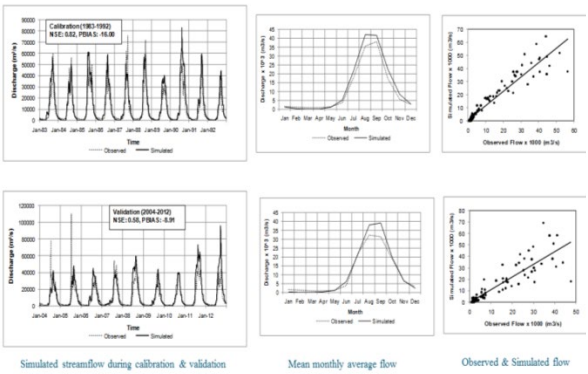
The main Objective:
Assessment of future water availability based on combined impact of climate change and anthropogenic interventions through hydrological model development and scenario analysis.

Methods



Expected results and conclusions

- Calibrated and validated hydrological model for Ganges basin.
- Future estimate of hydrological components – streamflow, water yield, ET, GW recharge.
- A robust hydrological scenario using four-quadrant matrix approach.
- Strategical revision to cope with future water diversion issues.



Simulated streamflow during calibration & validation | Mean monthly average flow | Observed & Simulated flow

E-mail: kazi.rahman@wur.nl

Water scarcity in the water-food-energy nexus: Developing scenarios to assess impacts, trade-offs and synergies

Researcher
Bram Droppers
2017-2021

Supervisors
Prof. Fulco Ludwig
Prof. Rik Leemans
Dr Michelle van Vliet

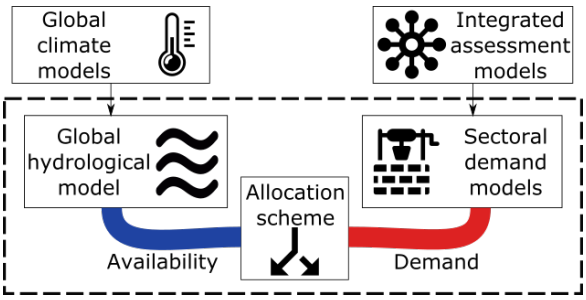
Research Challenges

Changes in climate, demography and lifestyles increase imbalances between water availability and water needs for agriculture, energy, manufacturing, livestock, households and ecosystems. Resulting water scarcity increases competition for water resources between different sectors and nations.

Assessing future water-scarcity impacts worldwide requires quantifying the consequences of such trends.

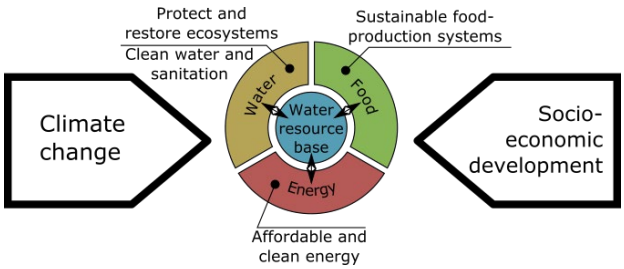
Methods

An integrated water-assessment framework will be developed. This framework consists of models for hydrology, crop cultivation, electricity production, sectoral water demands and allocation.



Results and conclusions

The integrated water-assessment framework will produce water-scarcity maps and identify trade-offs and synergies within the water-food-energy nexus for different scenarios up to 2050, which help to develop better water management strategies.



E-mail: bram.droppers@wur.nl

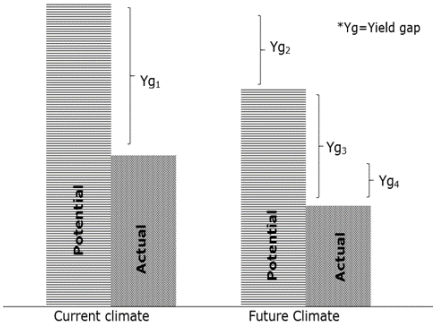
Impact of large scale implementation of climate smart agricultural interventions on climate resilience of different value chains and farming systems from an agricultural production and environmental perspective in East Africa

Researcher
Kitinya Kirina
2019-2023

Supervisors
Prof. Fulco Ludwig
Dr. Annemarie Groot
DR. John Recha

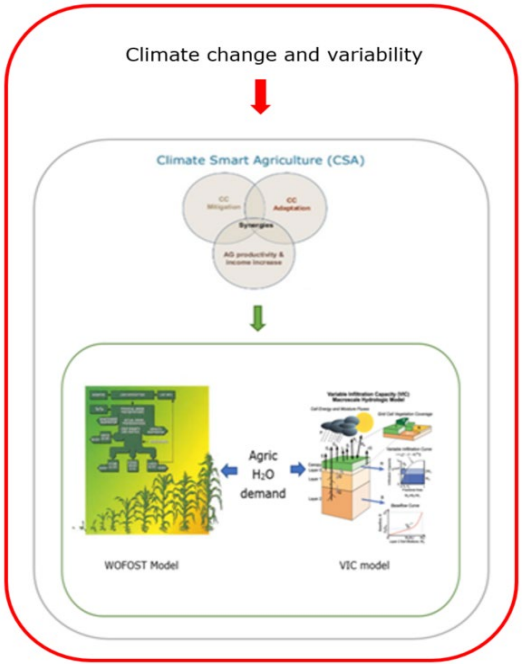
Research Challenges

Climate change and variability(CCV) is impacting agricultural systems negatively resulting in disruption of value chains, trade and agro -based industries. The project will strive to handle the issues surrounding farming systems especially impact of CCV on yield/yield gaps and their potential vibration on the entire value chain.



Climate smart agriculture(CSA) is a part of the solution. Less is understood on impact of adoption of CSA practise on value chain and at macro-level.

Methods



Results and conclusions

- Better understanding of CSA practices on crop performance, soil health and Environmental services for better value chain derisking.
- Assess impact of climate change on future yields to inform agriculture value chain investment decision.
- Water balance assessment for agricultural sustainability potential trade-offs.

E-mail: thomas.kirina@wur.nl

Modelling the effect of water pollution from human activities to freshwater ecosystems in Hai He Basin

Researcher
Jing Yang
(2017-2020)

Supervisors
Prof. Carolien Kroeze
Prof. Lin Ma
Dr Maryna Strokal

Research Challenges

Problems

- Freshwater ecosystem degradation
- Water shortage
- Lack of insight into the dynamics of seasonal nutrients output to freshwater systems

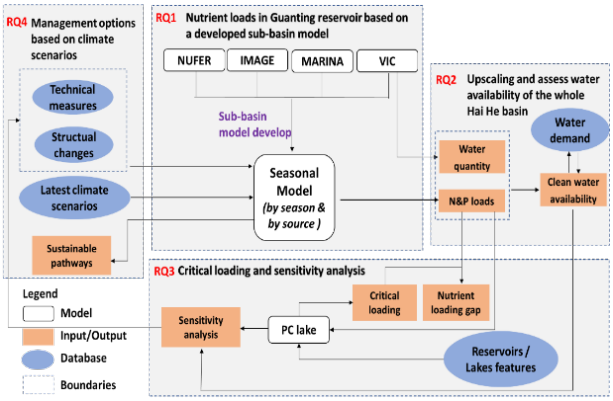
2.

Research objectives

The main objectives of this research are to improve our understanding (1) effect of nutrient pollution on water quality and water availability in the Hai He basin, and (2) of possibilities to reduce this pollution.

Methods

An integrated and quantitative assessment tool for management options to reduce nutrients loadings in surface water will be developed based on three complementary models: NUFER, MARINA and PC Lake.



Expected results

Assessment of:

1. Nutrient inputs by season and by source to the Guan Ting reservoir
2. Nutrient inputs to the large lakes and reservoirs and the effects of nutrient pollution on water availability in the Hai He Basin
3. How nutrient inputs affect the large lakes and reservoirs of the Hai He Basin
4. Combinations of technical measures and structural changes in agriculture in the Hai He basin to reduce the impact of nutrient inputs to rivers, lakes and reservoirs

E-mail: jing1.yang@wur.nl

Reducing point source inputs of nutrients to rivers and their impact on ecosystems and society in China

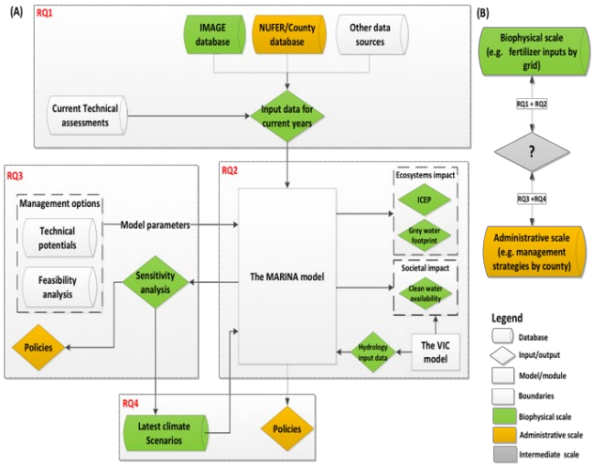
Researcher
Chen Xi (Coco)
(2016-2020)

Supervisors
Prof. Carolien Kroeze
Prof. Lin Ma
Dr Michelle van Vliet
Dr Maryna Strokal

Problem definition

- Point sources are major sources of water pollution in China; few studies explicitly consider manure as point source inputs to rivers.
- The linkages between water pollution and water scarcity are not well understood.
- Interpreting model results at biophysical scales at administrative scales is a challenge.

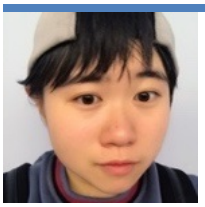
Methods



(A) Model development (B) Theoretical framework of multi-scale modelling.

Expected results

(1) An updated database for point sources inputs to waters in China
(2) An integrated model to assess the impacts on both water quality and water quantity in China
(3) Indicators for water quality and clean water availability
(4) Effectiveness of management options for point sources in related to local characteristics
(5) Scenario analysis based on latest climate and socio-economic scenarios.



Email: xi.chen@wur.nl

Nutrients and Pesticides in the Rivers of China: Pollution levels and solutions for them

Researcher
Ang Li

Supervisors
Prof. Carolien Kroeze
Prof. Ma Lin
Dr. Maryna Strokal

Research Challenges

Food production is a source of nutrients and pesticides in rivers.

Sustainable solutions for food production in China are needed: e.g., reducing over-fertilization and recycling manure on the land.

Modelling approaches can help to explore such solutions to reduce future river pollution.

Methods

MARINA: Model to Assess River Inputs of Nutrients to seAs.

A model to assess pesticide pollution in rivers.

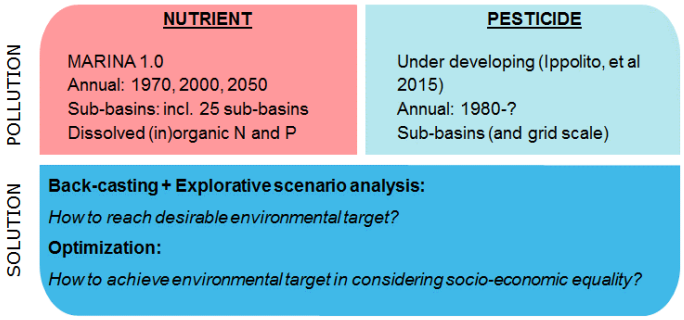


Figure 1. Research framework

Results

Example:

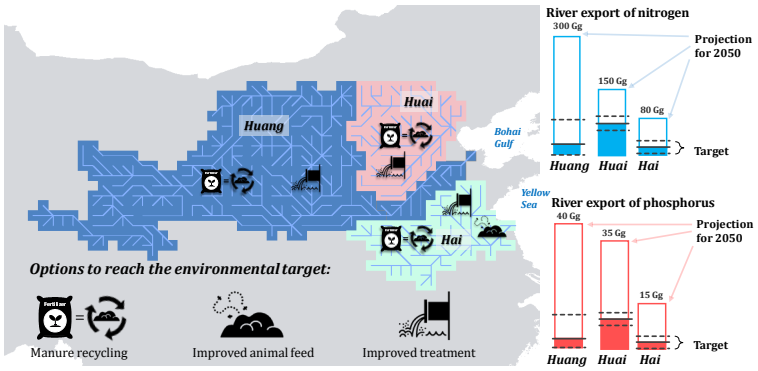


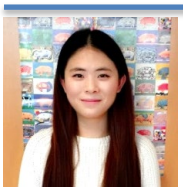
Figure 2. Reducing coastal eutrophication

Desired futures with low nutrient levels in water;

Solutions to reach desired futures:

- Manure recycling
- Improved animal feed
- Improved waste treatment

Li et al. (2019) How to avoid coastal eutrophication - a back-casting study for the North China Plain. Science of the Total Environment 692, 676-690



E-mail: ang.li@wur.nl

Modelling the environmental impact of nutrients on lakes in Yunnan

Researcher
Xiaolin Li

Supervisors
Prof. Carolien Kroeze
Prof. Yi Zheng
Prof. Lin Ma

Research Challenges

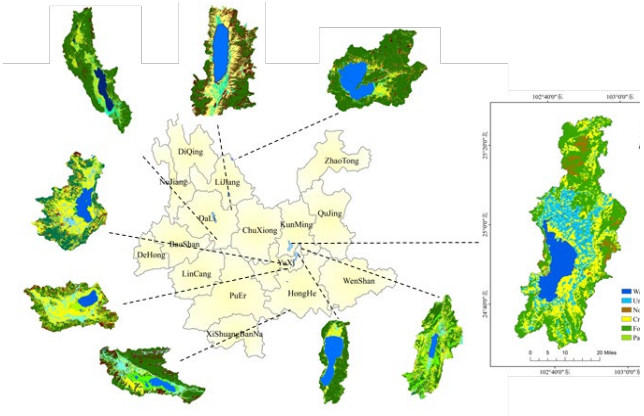
1) The eutrophication problem of the lakes in Yunnan province has become one of the major environmental issue that restrict local economic and social development.

2) Lakes in Yunnan province have smaller environmental capacity than coastal seas, so it is easier to suffer from eutrophication.

3）Detailed spatial information and long-term data for the lakes in Yunnan province is absent.

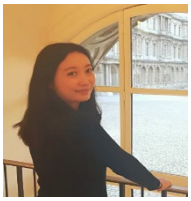
Methods

1. Apply MARINA model and PCLake model 2. Upscale the model for lake DIanchi to the other 8 large lakes
3. Scenario analysis to explore alternative future trends



Expected results and conclusions

Assessment of:
1. N and P inputs to lake Dianchi, and the impact of nutrients on water quality in lake Dianci
2. past and future N and P inputs to all nine large lakes in Yunnan
3. past and future water quality in other large lakes in Yunnan
4. sources and possible solutions for future eutrophication in the lakes of Yunnan



Email: Xiaolin.li@wur.nl

Modelling future nitrogen pollution from agriculture in the Yangtze River, China

Researcher
Xuanjing Chen
2017-2021

Supervisors
Prof. Carolien Kroeze
Prof. Xiaojun Shi
Dr Maryna Strokal

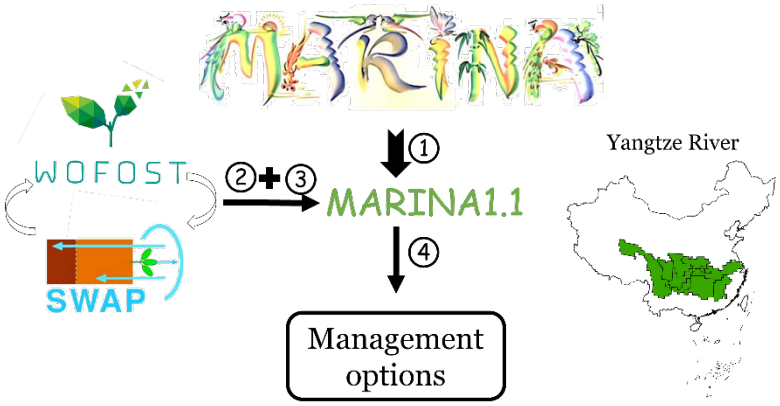
Research Challenges

1. The effect of seasonality on nitrogen export by the Yangtze River is still not well understood.

2. The contribution of different crop systems to water pollution is not well studied for the Yangtze River basin;

3. Maintaining food security with low environmental impacts on water quality in the Yangtze River basin is challenging in the coming years;

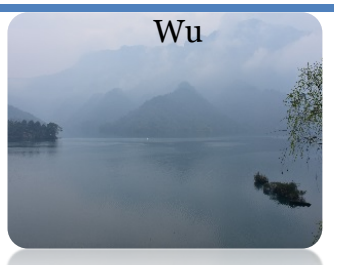
Methods

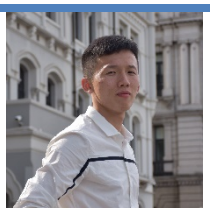


- MARINA : Model to Asses River Inputs of Nutrients to seAs
- WOFSOT: WOrld FOod STudies
- SWAP: Soil, Water, Atmosphere and Plant

Expected results and conclusions

1. Newly version of MARINA accounted for seasonal river export for N export will be developed;
2. Newly integrated modelling system of MARINA-WOFOST-SWAP will be developed;
3. The management options in agriculture to reduce nitrogen export by Yangtze will be explored.





E-mail: xuanjing.chen@wur.nl
cxj0214@email.swu.edu.cn

Smart Nutrient Retention Networks for good water quality and sustainable nutrient use

Researcher
Dianneke van Wijk
2018-2023

Supervisors
Prof. Dr. Carolien Kroeze
Prof. Dr. Wolf Mooij

Research Challenges

- Nutrients are a limited resource for food production but part of them are lost in the ocean.
- Nutrients cause water quality problems in surface waters.

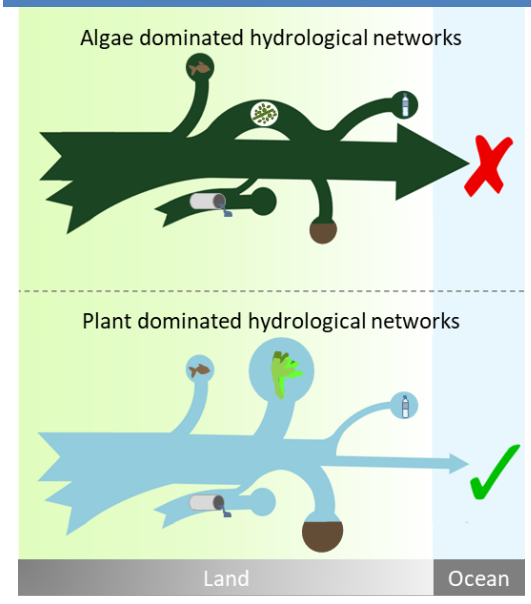
Objective

- Study the positive feedback loop between nutrient loading, water quality and nutrient retention in hydrological networks.
- Develop Smart Nutrient Retention Networks (SNRNs) to improve water quality and recycle valuable nutrients.

Methods

I will explore and demonstrate the potential of SNRNs through review of existing knowledge and models, nutrient retention network model development, scenario analysis at multiple scales and considering global change.

Expected results and conclusions



Smart Nutrient Retention Networks combine management strategies to optimize nutrient retention to reach network wide improved water quality.

Figure 1. Conceptual flow diagrams showing phosphorus flows in hydrological networks. In the algae dominated state phosphorus is lost to the ocean, but in water plant dominated systems retention in harvestable phosphorus sinks (spheres) reduces this loss.

E-mail: dianneke.vanwijk@wur.nl, dvanwijknioo.knaw.nl

Multi-pollutant assessment of water quality and food production for agricultural green development in China: an integrated, multi-scale modelling approach

Researcher
Yanan Li
2019-2023

Supervisors
Prof.Carolien Kroeze
Prof.Fusuo Zhang
Prof.Lin Ma
Dr Maryna Strokal
Dr Wen Xu

Research Challenges

Food production in China has increased. This holds especially for the North China Plain.

Agricultural activities are important **sources of environmental pollution** including rivers.

Agricultural Green Development is an opportunity to reduce water pollution and increase the sustainability of agricultural activities.

The main research objective is to assess future Agricultural Green Development in China, in terms of sustainable food production and multiple pollutants in water systems at different scales.

Methods

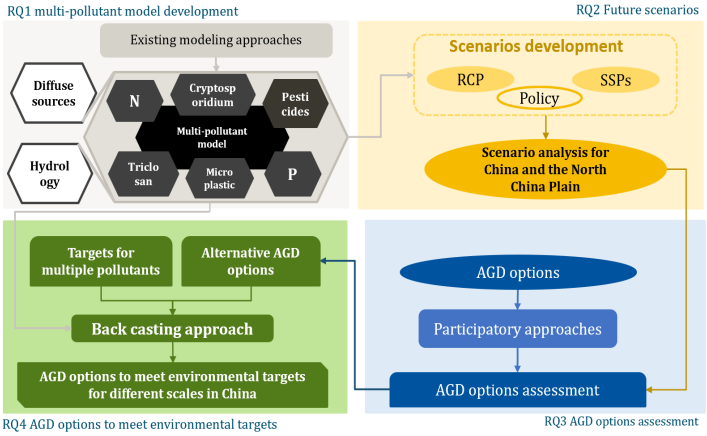
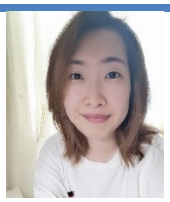


Figure 1. The research framework of the PhD thesis including four research questions (RQs). SSPs are Shared Socio-economic pathways. RCPs are Representative Concentration Pathways. AGD is agricultural green development. N and P are nitrogen and phosphorous, respectively.

Expected results and conclusions

(5) New version of the MARINA-Global model to assess inputs of multiple pollutants to surface waters by source and sub-basin;
(6) The multi-pollutant assessment of surface water quality in the world, China and North China Plain;
(7) Agricultural Green Development (AGD) options to reduce future water pollution;
(8) Recommendations for AGD development at different scales to support sustainable food production and water security in the future.



Email: yanan.li@wur.nl

yanan_li@yeah.net

Agricultural Green Development for Integrated nitrogen management of air and water in Quzhou and North China Plain

Researcher
Fanlei Meng
(2019-2023)

Supervisors
Prof. Carolien Kroeze
Prof. Fusuo Zhang
Prof. Lin Ma
Dr. Maryna Strokal
Dr. Wen Xu
Dr. Mengru Wang

Research Challenges

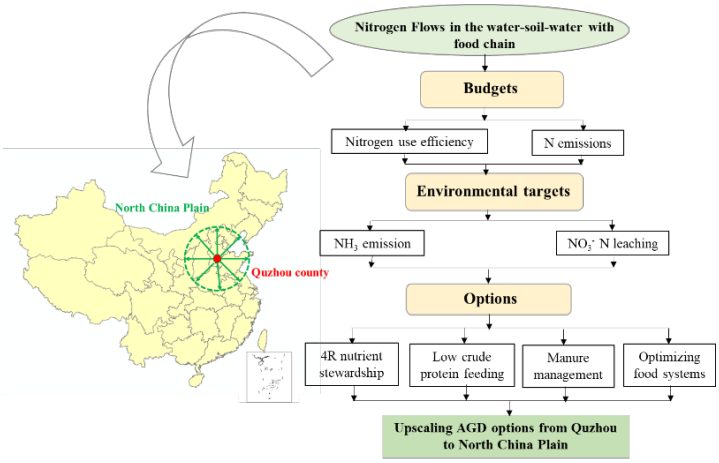
Problems
Lack of quantitative N flows in the food chain considering the air-soil-water interactions;

- Need for environmental targets for N flows;
- Need to explore Agricultural Green Development options to meet environmental targets.

Objective The main objective is to assess nitrogen flows in the water-soil-air interactions with the food chain and identify Agricultural Green Development options for meeting environmental targets for future N emissions in Quzhou and North China Plain

Methods

Figure 1. Research Framework.



Preliminary results and conclusions

1) Current nutrient use efficacies in Quzhou are low ;
2) The nitrogen losses are relatively higher in the following towns of Quzhou: Yizhuang and Dahedao;
3) Next steps are to improve the food chain model (NUFER) with local information to provide a spatially explicit assessment of nitrogen flows.

Email:fanleimeng2017@163.com

Connecting wide green dikes and vegetated foreshores in managed realignment

Researcher

Kim van den Hoven

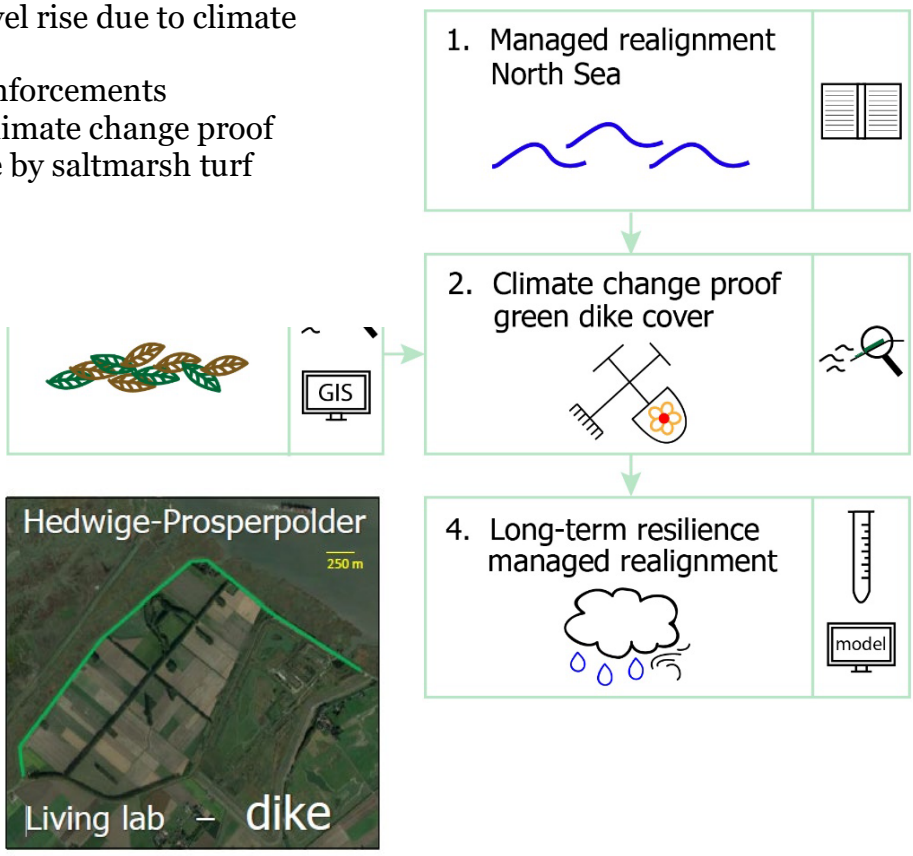
Supervisors

Prof. Dr. Carolien Kroeze
Dr. ir Jantsje van Loon-Steensma

Research Challenges

- Increasing sea level rise due to climate change
- Need for dike reinforcements
- Reintroduction climate change proof dike maintenance by saltmarsh turf application

Methods



Expected results and conclusions

- Improved knowledge on the climate adaptation measure managed realignment
- Increased understanding of dike and foreshore integration
- Guidelines for nature-based dike maintenance

E-mail: kim.vandenhoven@wur.nl

Using global model data to assess the Water-Energy-Food nexus under climate change

Researcher
Joreen Merks
2020-2023

Supervisors
Prof. Fulco Ludwig
Dr. Spyridon Paparrizos

Research Challenges

The water, energy and food sectors are strongly interrelated. An integral analysis is crucial to solve challenges within these sectors. Understanding these dynamics will become increasingly important as the pressure on our natural resources increase with population growth, socio-economic developments and climate change.
There is already a vast amount of literature and model data available on the separate sectors, however, quantitative cross-sectoral studies are still limited. Additionally, there is gap between the model data and the nexus indicators.

This project aims to utilize available global model data in assessing water-energy-food sector interactions.

Methods

This research will try to combine a demand driven and a supply driven approach to bridge the gap between global model data and indicators necessary to answer nexus questions.

- A global multi-model assessment with ISIMIP model data to identify global nexus hot spots for potential conflict and opportunity.
- Using a systematic literature review to identify current nexus indicators and methods.
- Do case study analysis with a multi-sector multi-model analysis to test the regional application of global model data in a nexus study

Expected results and conclusions

Within this research we want to gain insight into the possibilities of using global model data to answer water-energy-food nexus questions. We expect to link nexus indicators to the available model data. We expect to have global nexus hot spot maps based on multiple sectoral models and case study analysis for a regional context.

E-mail: joreen.merks@wur.nl

Educational principles in capacity building for climate services

Researcher
Maria del Pozo Garcia
2020 - n/a

Supervisors
Prof. Fulco Ludwig
Prof. Perry den Brok
Dr. Erik van Slobbe
Dr. Judith Gulikers

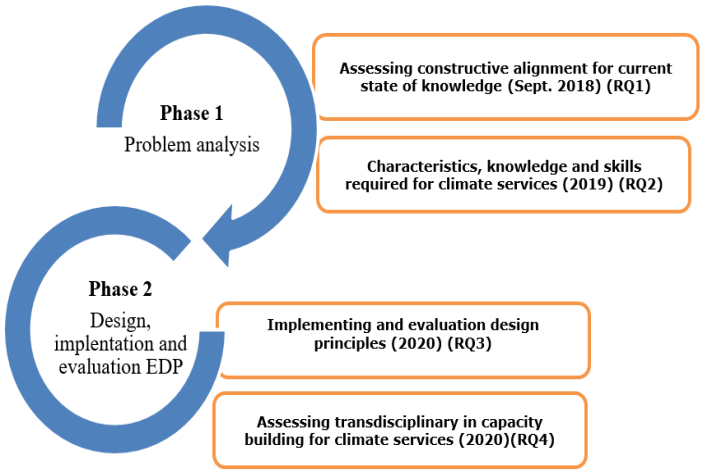
Research Challenges

Recently many climate data sources are becoming available to enable adaptation. However, improving data does not automatically lead to adaptation and co-production is needed.

Producing climate services for actionable knowledge requires a shift towards a two-way collaborative that is yet not explicitly included in capacity building.

In this research, we propose to explore the educational design principles that promote the shift in climate services paradigm.

Methods



Results and conclusions

Data users is an ambiguous term that embraces a wide background range with different and distinctive learning goals. The wide variety of users resulted in a shift towards group learning and collaboration, a distinctive feature from co-production of climate services. Capacity building needs to explicitly incorporate collaboration and flexibility to reduce the tendency towards science-driven climate services as opposed to demand or user-driven.

Contact details:
maria.delpozogarcia@wur.nl

How to make fire prevention enticing

Researcher
Hugo Lambrechts
2020 – 2024

Supervisors

Prof. Carolien Kroeze
Prof. Fulco Ludwig
Dr. Cathelijne Stoof

Research Challenges

Temperature increases in the north of Europe are leading to an increase in the frequency and extent of fires.
The main objective is to study the lesson fire prevention can learn from flood prevention and water management and explore other measures that make fire prevention more attractive enabling stakeholders and policy makers to take action and benefit society.

Methods

1) Evaluate the potential for using flood risk prevention to improve fire prevention.
2) Asses need for climate information services in fire prevention.
3) Use Payment for Environmental Services in fire prevention.
4) Creating a serious game for policy makers and land managers.

Expected results and conclusions

1) Recommendations for use of flood risk prevention and water management systems for improved fire prevention
2) Potential for adoption of climate information services in fire prevention.
3) Use of Payment for Environmental Services makes fire prevention more attractive.
4) A serious game that make fire prevention more attractive, enabling stakeholders and policy makers to take action.

E-mail: hugo.lambrechts@wur.nl

Environmental sustainability of Bangladesh shrimp industry in the context of climate change

Researcher
Abdullah-Al-Masud
2020-2023

Supervisors
Prof. Dr Fulco Ludwig
Dr Nynke Hofstra

Research Challenges

Shrimp industry of Bangladesh has extensive importance in economic and livelihood points of view.

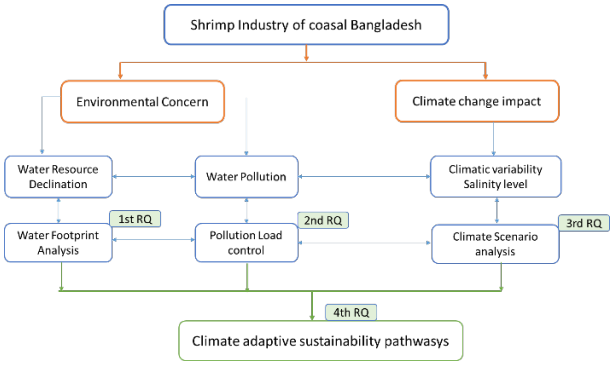
Despite having a huge opportunity, the Shrimp Industry of Bangladesh is struggling, one of the reasons is environmental unsustainability.

Moreover, recently, climate change also put a question mark on the sustainability of the industry.

This study intends to integrate the environmental concern and climate change to make the shrimp industry sustainable and climate adaptive.

Methods

The conceptual framework of the study is:



Results and conclusions

The overall goal of the study is to make the shrimp industry greener and climate adaptive to ensure its sustainability. Therefore, the study aim to explore the water footprint of the shrimp industry for better water management. Also, the pollution dynamics will be identify to explore the options to cleaner production. Then, future scenario analysis of climate change on shrimp industry will be analysed. Finally, a climate adaptive sustainability pathways will be formulate to help in the decision making, minimizing the uncertainties

E-mail: abdullahal.masud@wur.nl

Salt intrusion adaptation in the coastal zones of Bangladesh under changing climate.

Researcher
Md. Isfatuzzaman Bhuyan
2020-2024

Supervisors
Prof. Dr. Fulco Ludwig
Dr. Iwan Supit
Prof. Dr. Shamim Mia

Research Challenges

Salinity mainly affects land and water in the coastal areas. Crop production of the salt affected areas in the coastal regions differs considerably from non-saline areas. Due to increasing salinity in the water and soil, the people of the region are suffering from scarcity of safe irrigation water for agriculture and other uses. Crop yields, cropping intensity, production levels and people's quality of livelihood are much lower than that in other parts of the county.

Methods

- Saline water intrusion is mostly seasonal in Bangladesh winter months the saline front begins to penetrate inland, and the affected areas rise, so the variation of salinity will be accessed in the dry season of the coastal areas.
- Use SWAP model to access the impact of salinity in agricultural system
- Two potential cropping systems will be examined compare with the farmers existing cropping system based on profitability and risk.

Expected results and conclusions

This project aims at quantifying the impact of climate change on salinity intrusion and its effect on agriculture in the coastal areas of Barisal and Patuakhali district in Bangladesh using the SWAP model and primary data collection. Target-oriented measures will be identified for the projected impacts by synthesizing farmers' perceptions, current practices, expert opinions, and existing literature.

E-mail: md.isfatuzzaman.bhuyan@wur.nl

Appraising pathways for climate resilient development in semi-arid regions in India

Researcher
Arjuna Srinidhi
2019-2023

Supervisors
Prof. Dr. Fulco Ludwig
Prof. Dr. Miranda Meuwissen

Research Challenges

Semi-arid regions in India are characterised by agriculture-based livelihoods and an exposure to increasing frequency of extreme weather events. The uncertainties related to climate and socio-economic changes imply that a broad range of future scenarios needs to be considered for building resilience in these semi-arid regions. The aim of the project is to co-create and appraise pathways of actions towards climate resilience in semi-arid India.

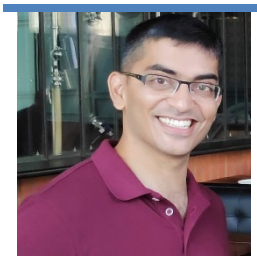
Methods

The project begins with the development of an appropriate resilience framework including indicators to operationalize it. We then proceed to assess the historical development trajectories which consist of watershed development projects. Next, insights from these retrospective assessments, along with future climate and socio-economic projections, are used to co-create climate resilient development pathways through a participatory, multi-stakeholder engagement process. Assessing the feasibility of the pathways across different levels of governance will be the final step in the work.

Results and conclusions

This project will bring in much needed understanding on climate resilient development in the context of semi-arid regions of India. The retrospective assessments as well as co-creation of climate resilient development pathways have the potential to guide government programmes that effect the livelihoods of vulnerable communities.

This project makes two contributions of scientific significance. One is the resilience assessment of historical development trajectories and the second is the demonstration of a pathways approach to building climate resilience.



E-mail: arjuna.srinidhi@wur.nl

Co-production of Agro-meteorological Information Services for Sustainable Agriculture in Ghana using Seasonal Forecasts and Digital Tools

Researcher
Talardia Gbangou
2016-2020

Supervisors
Prof. Fulco Ludwig
Dr. Erik van Slobbe
Prof. Godana Kranjac-Berisavljevic
Dr. Saskia Werners
Dr. Marcella D'Souza

Research Challenges

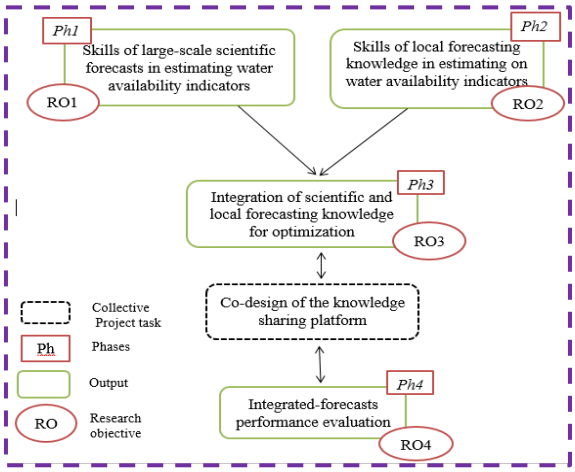
Problem definition:

- Climate variability and high dependence on rainfall for crop farming;
- Lack of relevant weather/seasonal forecasts information with appropriate indices, scale and lead-time for local farmers;
- Lack of integration between local and global forecasting local knowledge

The main objective:

- To improve weather and climate information services for small scale farmers by developing methods and tools that use and/or integrate local and scientific forecasting knowledge.

Methods



Results and conclusions

- New methods for verifying the skills of relevant and well scaled forecast-based agro-met indices.
- New methods for verifying the skills of local forecasting knowledge & integrating local and scientific forecasting knowledge
- Design criteria of a successful knowledge sharing system based on lessons learn from the evaluation of a co-production experiment

E-mail: talardia.gbangou@wur.nl

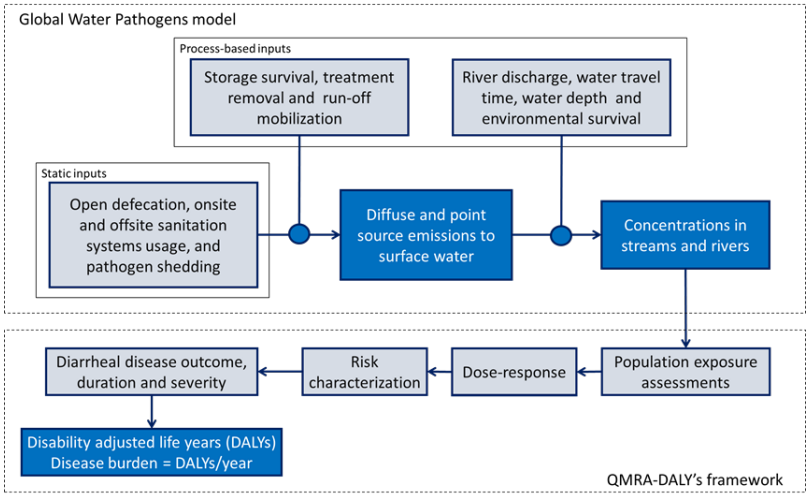
Assessing surface water contamination with rotavirus and associated disease burden from sanitation systems in Uganda

Researcher
Daniel Okaali
2018-2022

Supervisors
Prof. Dr. Carolien Kroeze
Prof. Dr. Gertjan Medema
Dr. Nynke Hofstra

Objectives

Uganda's low coverage of improved sanitation, poor wastewater treatment and disposal increase waterborne pathogens transmission via the faecal-oral route. The role of sanitation systems on surface water pathogen contamination, the associated disease burden and the influences from environmental change are less understood. With an example of rotavirus, our target, therefore, are to:



i) model rotavirus emissions and concentrations in rivers; ii) estimate the relative risk and diarrheal disease burden from exposures to modelled rotaviral pollution; iii) assess socio-economic and climate change impacts on modelled rotavirus output and the associated disease burden in Uganda.

Methods

We will adapt and use the existing water quality model (the Global Water Pathogens model), which integrates pathogen incidence, excretion, sanitation usage and wastewater treatment; together with the QMRA-DALY's framework using scenarios. The proposed analyses are applicable to other faecal pathogens in other locations, and will support decision making for sanitation and health related outcomes improvement.

E-mail: daniel.okaali@wur.nl

Agricultural Green Development pathways for food and water in China

Researcher
Qi Zhang
2019– 2023

Supervisors
Prof. Carolien Kroeze
Prof. Fusuo Zhang
Prof. Lin Ma
Dr. Maryna Strokal
Dr. Wen Xu

Objectives

Agriculture often discharges pollutants such as **antibiotics** into **surface and ground water.** This causes negative effects on nature and society.

The main research **objective** is to explore future **Agricultural Green Development pathways for clean wate**r in the North China Plain and China in the 21st century.

For this, a multi-pollutant model will be developed to quantify inputs of pollutants to surface and ground water today and in the future. Agricultural Green Development pathways will be developed and integrate optimistic solutions to increase the availability of clean water under sustainable agriculture in the North China Plain and China.

Methods

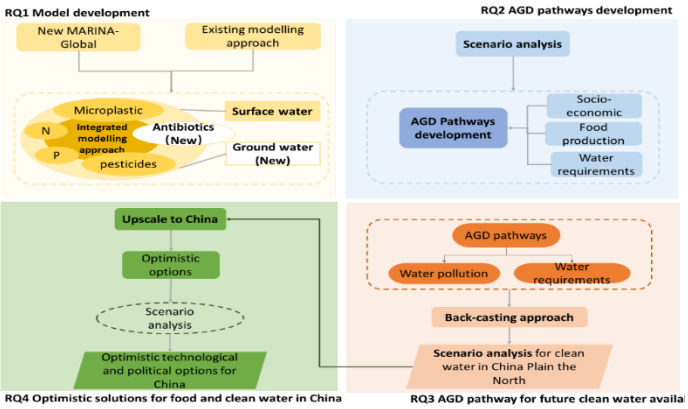


Figure 1 The research framework including four research questions (RQs). MARINA-Global is the Model to Assess River Inputs of pollutaNts to seAs by source from sub-basin in 2010. N is Nitrogen; P is Phosphorus; and AGD is Agricultural Green Development.

Expected Results

1: Model development for multiple pollutants from food production to surface and ground water in the North China Plain. The main focus is on antibiotics;

2: Develop Agricultural Green Development pathways for food production and water requirements in the North China Plain;

3: Assess the clean water availability under global change in the North China Plain;

4: Explore optimistic options under agricultural Green Development for clean water availability in China.

E-mail: qi.zhang@wur.nl; zhang_qi94@163.com

Quantifying the impact of flooding on waterborne pathogens and their health risk in Mexico City.

Researcher
Nancy Mondragon
2018-2022

Supervisors
Dr. Ir. Nynke Hofstra
Prof. Dr. Gertjan Medema
Prof Dr. Rik Leemans
Dr. Saskia Werners
Dr. Marcella D'Souza

Research Challenges

1. Calculation of microbial loads to the hydrological system;

2. Estimation of waterborne pathogens concentrations in a megacity's complex sewage network;

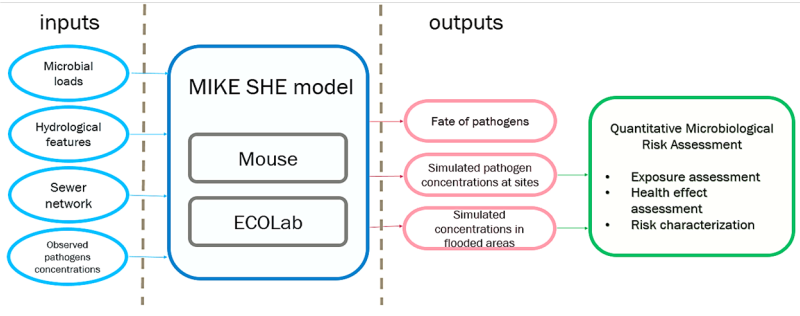
3. Waterborne pathogens presence in flood events;

4. Exposure assessment in flood events

Methods

Microbial loads will be calculated based on systematic literature reviews and used as an input. Hydrological features will be modelled using the MIKE SHE model (DHI).

The model will allow to simulate the fate and concentration of pathogens through the hydrological system and in flood events. A Quantitative Microbiological Risk Assessment will be carried out to identify hotspots and to estimate health effects.



Results and conclusions

1. A microbial water quality model for Mexico City;
2. Quantitative microbiological risk assessment that would be later used to approach floods in Mexico City as a public health issue;
3. Strategies and measurements to mitigate the overflow of waterborne pathogens in the city, developed through an scenario analysis.

Email: nancy.mondragon@wur.nl

Recent Graduates

WAGENINGEN
UNIVERSITY & RESEARCH

Nutrient Use Efficiencies of Food Production and Water Pollution in China

Researcher
Mengru Wang
(2014-2018)

Supervisors
Prof. Carolien Kroeze
Prof. Lin Ma

Motivation

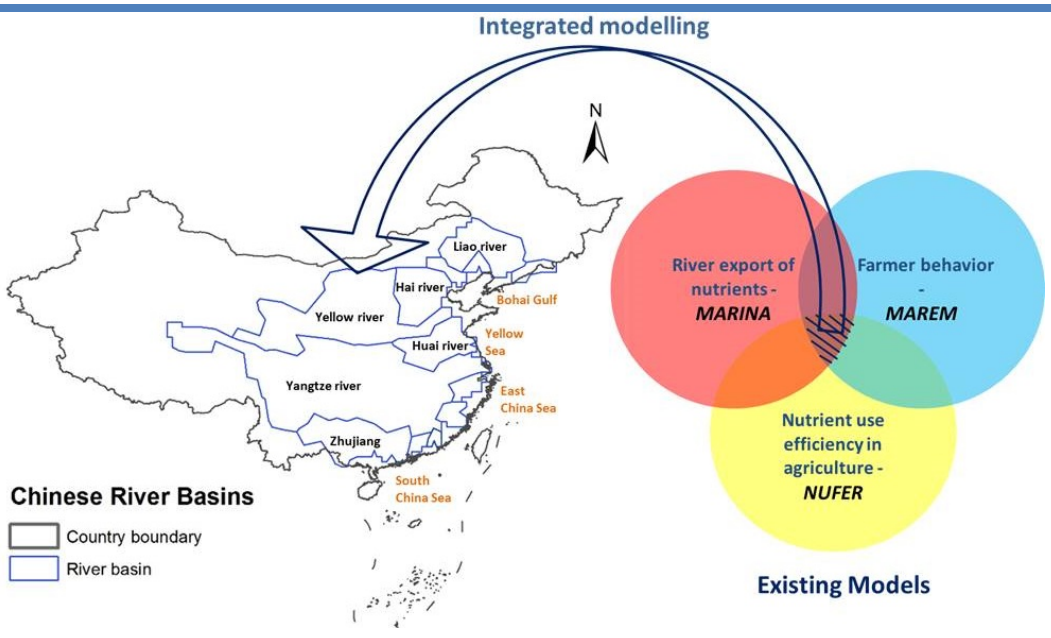
Nutrient use efficiencies of nitrogen (N) and phosphorus (P) are low in China. This has led to large N and P losses to aquatic systems, causing eutrophication in Chinese rivers and seas.

The **objective** is to explore nutrient management options to improve N and P use efficiencies of food production, and to reduce water pollution in China.

Research Challenges

- Model inputs
- Spatial scales
- Calibration and validation
- Region specific scenarios

Methods



E-mail: mengru.wang@wur.nl

Hydro-climatic Services for Improving Rice Farm Management Decisions in Ghana Using Seasonal Climate Forecast

Researcher
Emmanuel Nyadzi
(2016-2019)

Supervisors
Prof. Fulco Ludwig
Dr Saskia Werners
Dr Robbert Biesbroek

Research Challenges

- Over reliance on unpredictable rainfall affects rice farm management decisions of farmers and irrigation water managers in Ghana.
- Seasonal climate forecasts (SCF) have potential to insulate African farmers from climate shocks.
- SCF have no inherent value, unless it influences decision and impact on systems under consideration
- To avoid one directional approach of science, to produce end-users access, we use citizen science to co-produce the hydroclimatic-EVOCA with farmers.

Methods

Main Objective

To assess the potential of making seasonal climate forecast information actionable for rice farmers in northern Ghana

Expected results and conclusions

1. Hydroclimatic informational needs of rice farmers and the skills of ECMWF-S4 in meeting them.
2. The indigenous knowledge and mechanisms used by farmers in making local rainfall and yield predictions.
3. Predictability of seasonal water availability using seasonal climate forecast (ECMWF-S4)

E-mail: emmanuel.nyadzi@wur.nl

Towards sustainable local drinking water abstraction

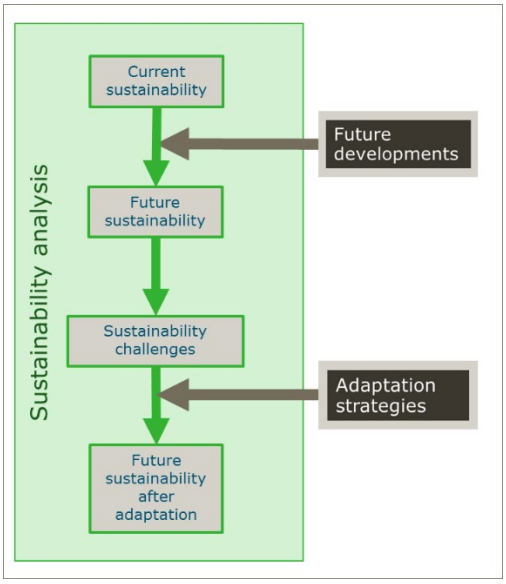
Researcher
Jolijn van Engelenburg (Vitens)
2016-2020

Supervisors
Prof.dr.ir. P.J.G.J. Hellegers
Prof.dr.ir. R. Uijlenhoet
Dr.ir. E.J.J. van Slobbe
Dr.ir. A.J. Teuling

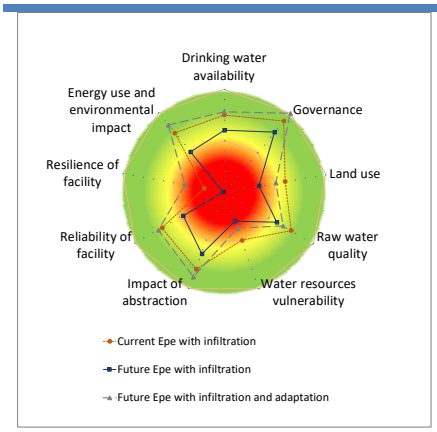
Research Challenges

The sustainability of local drinking water abstractions is under pressure by future developments such as climate change and a growing drinking water demand. Drinking water companies need to decide on adaptation options to secure these abstractions for the future. To understand the sustainability of a local drinking water abstraction, socio-economic as well as physical and technical aspects are relevant. Before deciding on adaptation, the impact of future developments and adaptation measures to the sustainability of a local drinking water abstraction must be assessed.

Methods



Results and conclusions



Using the sustainability assessment framework can support decisions on adaptation to future developments. The importance of taking into account future developments such as climate change is demonstrated in a Veluwe case study showing the significant long-term impact of climate change on relocation of groundwater abstractions. Infiltration (Managed Aquifer Recharge) is successfully used as an adaptation option to reduce the hydrological impact of the drinking water abstraction Epe in the Netherlands. However, evaluation identified the vulnerability of the infiltration for water quality deterioration and water availability. The sustainability assessment framework shows that although certain sustainability aspects improve by the infiltration, it also causes a deterioration of other sustainability aspects.

E-mail: jolijn.vanengelenburg@wur.nl

Van Engelenburg, J., Hueting, R., Rijpkema, S., Teuling, A. J., Uijlenhoet, R., & Ludwig, F. (2017). Impact of Changes in Groundwater Extractions and Climate Change on Groundwater-Dependent Ecosystems in a Complex Hydrogeological Setting. Water Resources Management, 1-14.

Van Engelenburg, J., Van Slobbe, E., & Hellegers, P. (2019). Towards sustainable drinking water abstraction: an integrated sustainability assessment framework to support local adaptation planning.

Climate-change effects on the Zambezi teak forests' productivity in Zambia

Graduated 2019 11 June

Researcher
Justine Ngoma
2012-2019

Supervisors
Prof. Rik Leemans
Dr Eddy Moors
Dr Bart Kruijt
Dr Royd Vinya

Research Challenges

Southern Africa:

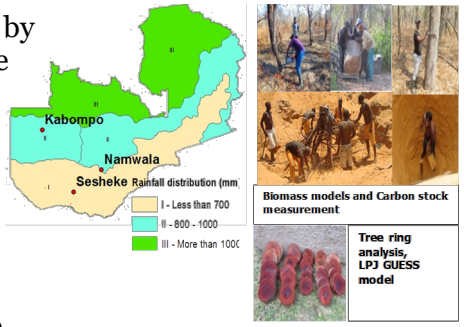
- Rainfall has reduced and is projected to reduce by more than 10% by 21st century above the 1986-2005 baseline.
- Temperature has increased and is projected to increase by more than 3.4°C by the end of the 21st century above the 1981-2000 baseline

Aim: To determine the effects of climate change on the productivity of the Zambezi teak forests in Zambia

Objectives

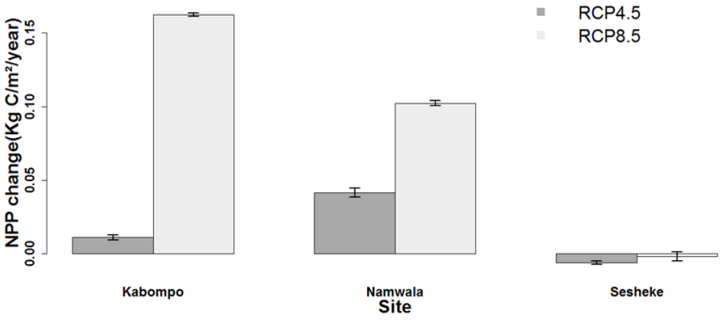
1. To develop above and below ground biomass models
2. To evaluate carbon stocks of the Zambezi teak forests.
3. To examine the sensitivity of the Zambezi teak forests to climate change

Methods

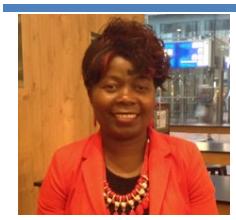


Results and conclusions

Projected changes in NPP



- *NPP is projected to increase at the wetter Kabompo and intermediate Namwala sites under RCP 4.5 and RCP 8.5 especially caused by the increased CO_2 concentration by the end of the 21st century,*
- *At the drier Sesheke site, NPP would decrease by the end of the 21st century under RCP 4.5 and RCP 8.5. The projected decreased NPP under RCP8.5 results from the reduced rainfall coupled with increasing temperature.*
- *The projected increase in carbon dioxide concentration would have more effects on NPP in high rainfall receiving areas, while in arid regions, NPP would be affected more by the changes in rainfall and temperature.*



E-mail: justine.ngoma@wur.nl, justinangoma@yahoo.com

Hydrological functioning of Tropical Montane Cloud Forests in the Orinoco river basin

Graduated 2018 30 Jan

Researcher
Beatriz Ramírez

Supervisors
Dr. Laurens Ganzeveld
Dr Ryan Teuling
Prof. Rik Leemans

Research Challenges

The Tropical Montane Cloud Forests (TMCF) in the Orinoco River basin are unique because they are located upwind from the seasonally flooded savannahs in the basin's lowlands, in contrast to the TMCF more south on the eastern Andes located upwind from the amazon forests. However, little is known about their hydrological functioning and the impacts land-use and climate change can have on their hydrology.

Methods

We setup a data collection system: meteorological stations, rainfall, fog, throughfall and streamflow gauges, and soil moisture sensors in three neighbouring TMCF catchments with contrasting forest cover (2013-2017). We collected organic and mineral soil samples.
All these data, coupled with modelling has allowed us to better understand the hydrological functioning of these forests.

Main results and conclusions

At higher elevations (2140 masl) conditions are wetter than at the lower elevations (1840 masl) even during the dry season. Fog/rainfall persistence is crucial for dry season streamflows
The soil organic layers have a larger water storage than the canopy, and their absence due to deforestation define the higher peakflows in the deforested catchment

Expected longer dry seasons can cause critical low levels of soil moisture affecting TMCF survival.
Fog inputs are relatively low in contrast to other TMCF, however it plays an important regulatory role as it reduces evapotranspiration and partially fills the canopy storage increasing the amount of precipitation that reaches the ground.

E-mail: beatriz.ramirezcorreal@wur.nl

Impacts of Climate Change on Coastal Ecosystems of Bangladesh

Graduated: 2018 4 Apr

Researcher
Peerzadi Rumana Hossain
(2012-2017)

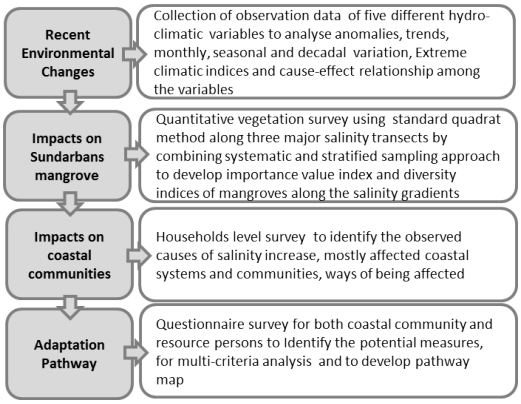
Supervisors
Prof. Fulco Ludwig
Prof. Rik Leemans

Research Challenges

Challenge
The methodology adopted is pioneering for climate change impact study on an ecosystem focussing the relationship and dependency of its components with one another.

Objectives
Recent environmental changes in south-west coastal region of Bangladesh;
Impacts of salinity increase on Sundarbans mangrove and coastal people;
Develop adaptation pathway for salinity risk reduction in south-west of Bangladesh.

Methods



Main results and conclusions

Salinity increase is driven by a range of processes i.e., rising temperature, daily precipitation intensity index, reduced upstream flow and sea-level rise.

Further changes in salinity gradient will favour a shift in mangrove composition towards more salt tolerant species with reduced biodiversity.

Crop agriculture, Sundarbans mangrove and drinking water sources and health are the mostly affected coastal systems by salinity increase.

Trends of different hydro-climatic

Parameters	Trend	Time Series	Years
Maximum temperature	+ 0.03 ^{0}C yr^{-1}	1981-2010	30
Minimum temperature	+ 0.02 ^{0}C yr^{-1}	1981-2010	30
Precipitation	-6.559 mm yr^{-1}	1981-2010	30
Effective Sea level rise	+10.3 mm yr^{-1}	1981-2010	30
Salinity (high tide)	+0.4 ppt yr^{-1}	2000-2008	9
Salinity (low tide)	+0.5 ppt yr^{-1}	2000-2008	9
Fresh water discharge (Post Farakka)	-4187.5 cumec yr^{-1}	1976-2010	35

Diversity Indices for three different salinity

Indices	Transect 1 (South East)	Transect 2 (South Central)	Transect 3 (South West)
Species Richness (S)	12	10	7
Shannon-Wiener's Diversity Index (H)	1.675	1.607	0.965
Shannon's equitability (E_H)	0.674	0.698	0.496
Simpson's Diversity Index (D)	4.350	3.930	2.270
Simpson's Equitability (E_D)	0.363	0.393	0.324

E-mail: rumana.hossain@wur.nl

Living in Future: How much water do we really need?

Graduated 2017 20 Dec

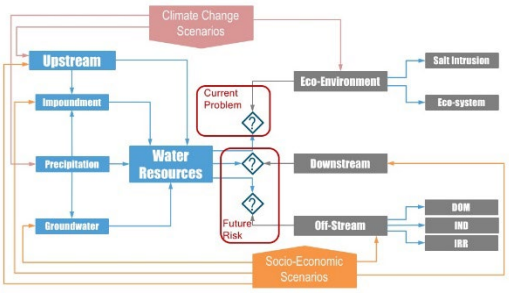
Researcher
Yao Mingtian

Supervisors
Dr Saskia Werners
Dr Ronald Hutjes
Prof. Pavel Kabat

Research Challenges

Objective
Obtain better understanding of the sectorial water use development, and to identify the driving forces and associated uncertainties in water use under future changing climate and socio-economic development at the regional scale, with the Pearl River Basin (PRB) as a case study.

Methods



Main results and conclusions

The Pearl River Delta stabilized total water use, regardless its rapid socio-economic development.
Salt-intrusion induced water shortage could be alleviated by water use management.

Downscale procedure is needed before using the globally developed scenarios for regional assessment.
Water conflicts exist between different water users in the PRB under future climate change and socio-economic development.

E-mail: mingtian.yao@wur.nl

Entrepreneurship in ecosystem-based adaptation to climate change

Graduated 2018 7 May

Researcher
Debora de Block

Supervisors
Prof. Peter Feindt
Dr Erik van Slobbe

Research Challenges

Ecosystem-based Adaptation (EbA) is a novel approach that helps society adapt to climate change through conserving, restoring and creating ecosystem services. Uncertainty about the long-term effects of EbA measures, challenges both public and private actors. For adaptation to become successful we need to better understand entrepreneurial strategies to create and exploit opportunities and condition for success.

Methods

We conduct in-depth case studies using interviews and observations of entrepreneurs and document analysis. To overcome the limitation of having only qualitative analysis of a small set of case studies (making generalisation difficult) we apply Qualitative Comparative Analysis. This method uses formalised ranking rules to identify necessary and sufficient conditions for a certain outcome, in our research the opportunity creation process in EbA.

Results and conclusions

Entrepreneurial strategies for opportunity creation in EbA are analysed. Conditions for successful creation of new goods, services and new governance arrangements are ranked in terms of necessity.
Further, the process of shaping these conditions in a multi-party innovation project setting is analysed.

E-mail: debora.deblock@wur.nl

Combined effects of climate change and human activities on water resources allocation of the Pearl River basin, China

Graduated 2017 20 Dec

Researcher
Dan Yan

Supervisors
Dr Saskia Werners
Prof. Fulco Ludwig
Prof. Pavel Kabat

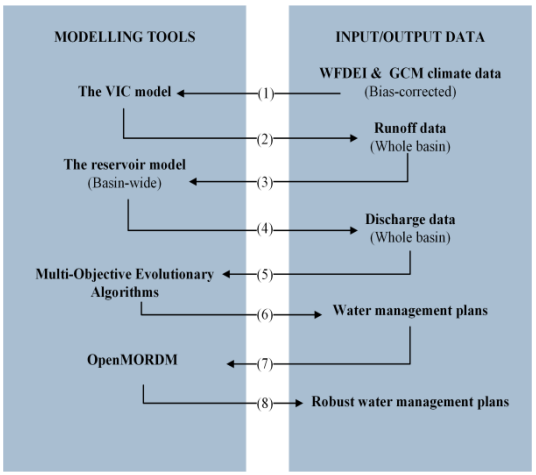
Research Challenges

Problem definition:

1. How does climate change affect water resources in the Pearl River basin?
2. How to develop robust water allocation plans for the basin?

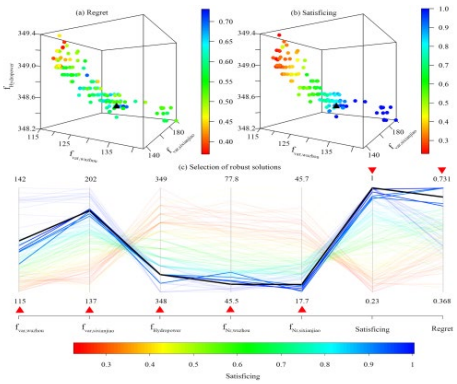
Main objective:
To identify and assess robust water allocation plans for the basin to reduce water scarcity and limit salt water intrusion in deltas.

Methods



Main results and conclusions

1. Climate change is likely to impact future flows of the Pearl River. Dry seasons are projected to become drier throughout the basin.
2. A Robust Assessment Model for Water Allocation was developed to support decision making about water release of different key reservoirs under future climate change.
3. Robust decision making using carefully selected MOEAs can help limit water shortages and salt intrusion in the Pearl River Delta.



Robustness assessment of water allocation plans under climate change uncertainties during the period of 2079-2084. Panel (a) and (b) show two different robust measures: regret (a) and satisficing (b). Panel (c) shows the selected robust water allocation **plans.**

E-mail: dan.yan@wur.nl

Future Irrigation Water Requirements in the Northwest Zone of Bangladesh: Developing Scenarios and Analysing Adaptation Strategies

Graduated Researcher
Tapos Kumar Acharjee

2018
11 Dec

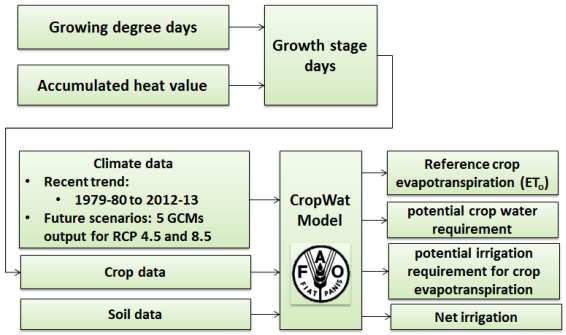
Supervisors
Prof. Fulco Ludwig
Prof. Petra Hellegers
Dr Gerardo van Halsema

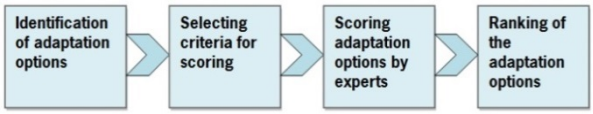
Research Challenges

Main objectives:

- To identify recent trends of water requirements of main dry season crop.
- To develop future scenarios of water requirements of main dry season crop.
- To identify and rank adaptation strategies for North-West Bangladesh.
- To develop possible adaptation pathways for North-West Bangladesh.

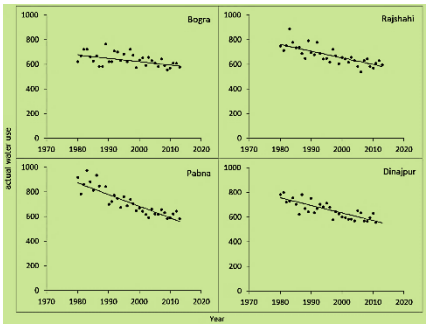
Methods





Expected results and conclusions

- Declined recent trends of crop water requirement (CWR) instead of an increase in temperature because of changes in humidity, wind-speed and sun-shine hours.
- Results indicate a reduction in future CWR also, mainly because of shortening growing days of *Boro* rice.
- Variable changes in future irrigation requirement because of variable rainfall in different models.
- Adaptation strategies for North-West Bangladesh will be identified and ranked.



Recent trends of potential crop water requirement of Boro rice

E-mail: tapos.acharjee@wur.nl

Preserving the World Second Largest Hypersaline Lake under Future Irrigation and Climate Change

Graduated 2017 29 May

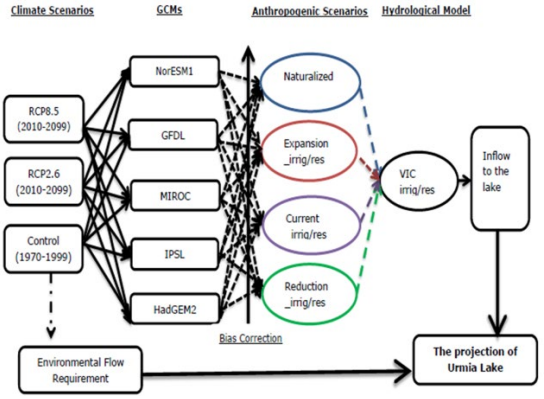
Researcher
Somayeh Shadkam

Supervisors
Prof. Fulco Ludwig
Prof. Pavel Kabat
Dr Pieter van Oel

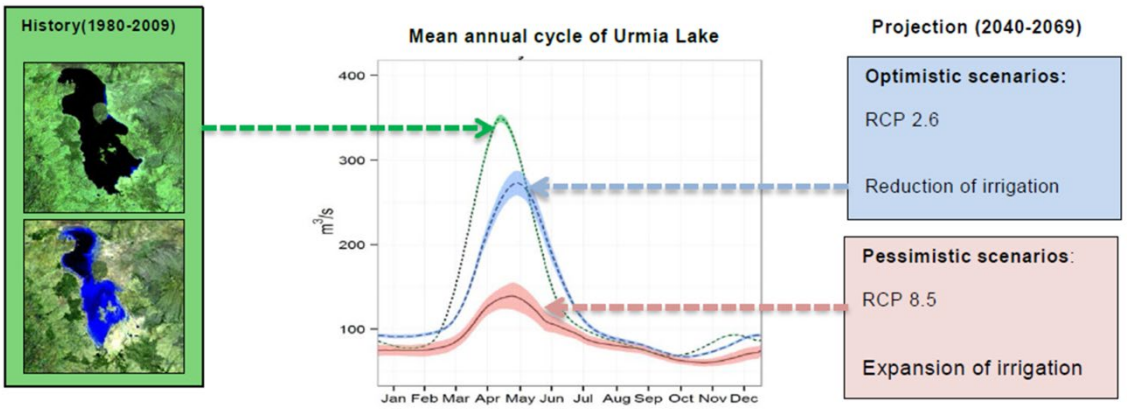
Research Challenges

- Urmia Lake desiccation is on the verge of triggering a socio-environmental disaster.
- The new official policy aims to increase inflow by cutting of irrigation water use substantially.
- It is still unclear if the water use reduction plan, which is about to start and has large socio-economic impacts, is able to restore and preserve the lake under future climate change.

Methods



Main results and conclusions



Email: somayeh.shadkam@wur.nl

The Mekong's future flows: Quantifying hydrological changes and developing adaptation options

Graduated 2017 12 Apr

Researcher
Long P. Hoang

Supervisors
Prof. Pavel Kabat
Prof. Rik Leemans
Prof. Fulco Ludwig
Dr Michelle van Vliet

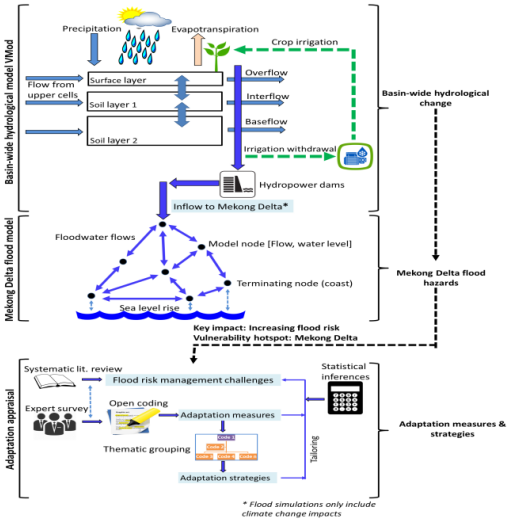
Research Challenges

- The international Mekong River faces critical challenges caused by climate change and rapid socioeconomic developments.
- Prevalent uncertainties exist in the future hydrological changes & associated risks.
- Anticipatory adaptation to hydro. changes requires effective measures & strategies

Research objectives

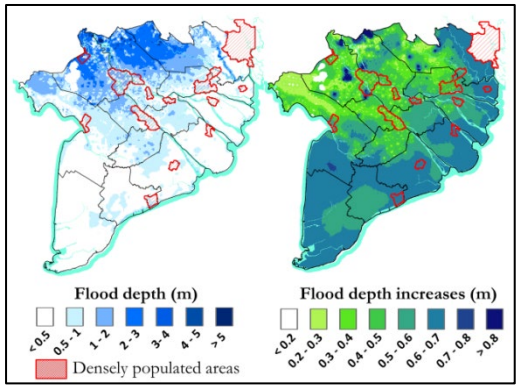
1. To quantify future hydrological changes in the Mekong basin;
2. To develop measures and strategies to adapt to the projected hydrological changes.

Methods



Main results and conclusions

1. The future flow regime shows substantial changes, characterized by (1) altered annual & seasonal flow dynamics and (2) changes in extremes (i.e. increasing floods & higher dry season flows)
2. Hydro. changes largely driven by impact interactions of climate change and human developments. This motivates active flow regime management through cross-sectoral water use optimisation.
3. Increasing flood risks in the Mekong Delta can be managed through combining (1) optimised & innovative flood control infrastructures with (2) improved governance and institutional capacities.



Future extreme floods (500 yr return period) increase safety risks for densely populated areas (> 1000 people km^{-2}) in the Vietnamese Mekong Delta.

Email: long.hoang@wur.nl
Mobile No.: +31 62 246 2599

How to sustain water for food and ecosystems under global change?

Graduated 2017 30 May

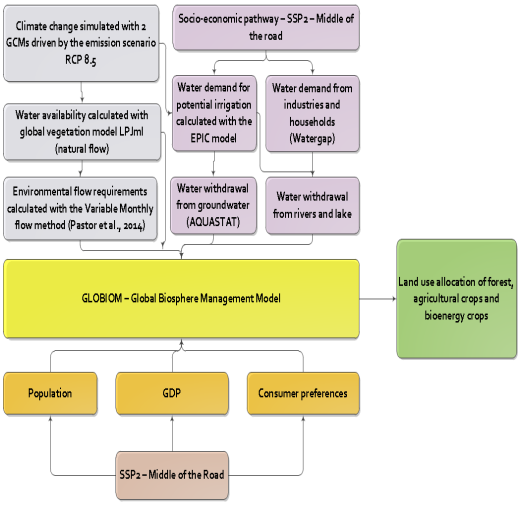
Researcher
Amandine V. Pastor
(2011-2017)

Supervisors
Prof. Fulco Ludwig
Prof. Hester Biemans
Prof. Pavel Kabat

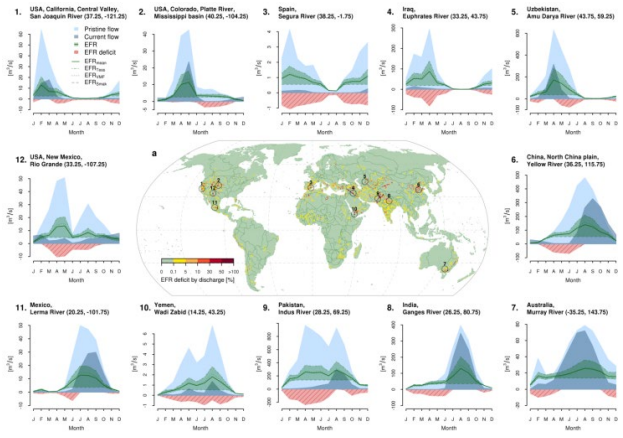
Research Challenges

1. Design a global method for calculating water requirement for ecosystems known as: "Environmental Flow Requirements (EFRs)" at global scale
2. Estimate Environmental flow deficit
3. Estimate impact of implementation of EFRs on food security
4. Calculate trade-offs between land use, water use and trade to satisfy both ecosystems and food

Conceptual framework of methods and models



Main results and conclusions



1. We identified hot-spots with high water stress for freshwater ecosystems and potential high risk of food insecurity in Asia and Mediterranean areas.
2. By 2050, under global change, we need to increase by 15% international trade, reduce water use by 50% and expand agricultural cropland by 20% to safeguard water for food and ecosystems.

mail: amandine.pastor22@gmail.com, fulco.ludwig@wur.nl

WSG Staff

prof. C. (Carolien) Kroeze

prof. F. (Fulco) Ludwig

dr. E.J.J. (Erik) van Slobbe

dr. R.W.A. (Ronald) Hutjes

dr. L.W.A. (Bert) van Hove

dr. J.M. (Jantsje) van Loon-Steensma

dr. B. (Bart) Kruijt

dr. I. (Iwan) Supit

dr. N. (Nynke) Hofstra

W.H.P. (Wietse) Franssen MSc.

MA. (Maartje) Sijtsema

Dr. I. (Inge) de Graaf

dr. M. (Mengru) Wang

J. (Joreen) Merks MSc.

dr. A.B.G. (Annette) Janssen

dr. M. (Maryna) Strokal

dr. W. (Wouter) Greuell

M. (Maria) del Pozo Garcia MSc.

dr S. (Spyros) Paparrizos

dr. S.E. (Saskia) Werners

dr. E. (Eveline) van der Linden

dr. P.L. (Long) Hoang

prof. P. (Pavel) Kabat

dr. M.T.H. (Michelle) van Vliet (Guest)

dr. D.H. (Dirk) Hoekman

dr. H. (Hasse) Goosen (Guest)

dr. H. (Hester) Biemans (Guest)

ing. BM (Boukje) Hackmann

dr. B. (Bregje) van der Bolt

H.S. (Hanne) Berghuis MSc.

L. M. (Lisanne) Nauta MSc.

dr. E. (Emmanuel) Nyadzi

dr. R. (Raffaele) Vignola

Contact Information

Visiting address:	Lumen Building 100 Droevendaalsesteeg 3 6708 PB Wageningen The Netherlands
Postal address:	P.O. Box 47 6700 AA Wageningen The Netherlands
Secretary:	MA (Maartje) Sijtsema (maartje.sijtsema@wur.nl)
Phone:	+31 (0) 317 484190
Fax:	+31 (0) 317 419000
Website:	http://www.wur.nl/wsg