WAGENINGEN
UNIVERSITY & RESEARCH

EARTH SYSTEMS AND GLOBAL CHANGE (ESC) GROUP

2024

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About
Earth Systems and Global Change (ESC)

Our mission:
To improve the understanding of the impacts of global change on Earth systems to contribute to sustainable futures.

Our ambitions:

- To improve our understanding of Earth systems in a changing global environment
- To investigate the impacts of a changing global environment on nature and society
- To contribute to the development and implementation of innovative tools, models and methods to better manage environmental systems
- To investigate land and water based options to mitigate global change
- To develop and assess sustainable measures and pathways to adapt to these futures
- To educate students in land, water and climate systems, global change and biodiversity and in inter- and transdisciplinarity
- To engage in finding solutions for land, water, climate and biodiversity problems
- To facilitate a transition towards sustainable systems worldwide

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People

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About
Earth Systems and Global Change (ESC)

Welcome to our group

Humans have profound influence on Earth's systems: land, water, climate, and nature. This interaction, termed Global Change, drives environmental and societal shifts worldwide, impacting all life on our planet. Through our work, we contribute to a better understanding of the challenges and to pioneer actionable solutions.

Our office is situated in the Lumen building on the campus of Wageningen University & Research. You are welcome to visit!

Education
Earth Systems and Global Change (ESC)

The Earth Systems and Global Change Group offers a diverse educational programme in the fields of 'Environmental Systems Analysis' (ESA) and 'Water Systems and Global Change' (WSG).

ESA education

WSG education

Contact persons

Jana Verboom – Education
Aritta Suwarno - MSc theses
Wichertje Bron - Internships
Keith Williams - Internships

Nynke Hofstra - Education
Maria del Pozo Garcia - MSc theses
Wouter Smolenaars - MSc theses
Keith Williams - Internships

ESA Education

Education is within the core business of our ESC group, and we contribute to many programmes and courses. Below is an overview of courses we coordinate. Besides these courses, we welcome students to do their thesis or internship under our supervision. Follow the QR code for details.

Thesis **Internship**

BSc programmes

- BSc Environmental Sciences
- BSc Tourism

MSc programmes

- MSc Environmental Sciences
- MSc Climate Studies
- MSc Urban Environmental Management
- MSc Tourism, Society and Environment
- MSc Biology

Courses

- ESA-10309 Environmental Sciences and Society
- ESA-11306 Environment & Tourism
- ESA-11806 Tourism Geographies
- ESA-20506 Introduction to Environmental Systems Analysis
- ESA-20806 Principles of Environmental Sciences
- ESA-22303 International Study Visits Environmental Sciences
- ESA-22806 Environmental Systems Analysis: Methods and Applications
- ESA-23806 Tourism Systems Analysis
- ESA-31306 Regional Environmental Management
- ESA-31806 Environmental Assessments of Nutrient and Pollution Management
- ESA-32306 Engaging and modelling with stakeholders to solve environmental problems
- ESA-60312 European Workshop Environmental Sciences and Management

WSG Education

Education is within the core business of our ESC group, and we contribute to many programmes and courses. Below is an overview of courses we coordinate. Besides these courses, we welcome students to do their thesis or internship under our supervision. Follow the QR code for details.

Thesis & Internship

BSc programmes

- **BSc Marine Science and Environmental Science**

MSc programmes

- **MSc International Land and Water Management**
- **MSc Climate Studies**
- **MSc Environmental Sciences**
- **MSc Urban Environmental Management**

Courses

- **WSG 10306 Global Water Systems and Climate Change**
- **WSG 20306 Climate Change Studies Topics and Approaches**
- **WSG 21306 Global Marine Compounds, Flows and Cycles**
- **WSG 33806 Integrated Water Management**
- **WSG 34806 Climate Change Adaptation in Water Management**
- **WSG 35306 Modelling Future Water Stress**
- **WSG 35806 Climate Smart Agriculture**
- **WSG 36306 Assessment of Marine Nature Based Solutions**
- **WSG 51306 Adaptation and Mitigation Services for Society**
- **WSG 52306 Disaster Risk Management and Nature Based Solutions**
- **WSG 60812 Design of Climate Change Mitigation and Adaptation Strategies**

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Research

The Earth Systems and Global Change Group is a solution-oriented multidisciplinary research group focusing on sustainability and global change.

Global change

We live in the Anthropocene – an era defined by profound human influence on Earth's systems: land, water, climate, and nature. This interaction, termed Global Change, drives environmental and societal shifts worldwide, impacting all life on our planet. There is a need to dissect and comprehend the intricate dynamics and interplay between the five Earth systems – land, climate, water, nature, and society – across local, regional and global scales.

Our approach

At Earth Systems and Global Change, our research and teaching revolves around comprehensive integration. We generate knowledge across these systems, employing innovative systems analysis tools and quantitative and qualitative approaches for data collection, modelling, and integrated assessment. Our approach spans diverse stakeholders, embracing inter- and transdisciplinarity to enact real change. Through our work, we contribute to a better understanding of the challenges posed by Global Change but also to pioneer actionable solutions, empowering communities and policymakers to create a resilient and sustainable future for all.

Group structure

The Earth Systems and Global Change Group is divided in seven different subgroups. Each focusses on a specific topic related to (Sustainable) Earth Systems and Global Change. The subgroups are led by two chairs in Environmental Systems Analysis (ESA) and Water Systems and Global Change (WSG), each with distinct teaching programmes.

Our subgroups

We have seven different subgroups. Each subgroup focusses on a specific topic related to (Sustainable) Earth Systems and Global Change.

BES

CSA

ESF

LBM

NFE

WCF

WQ

BES: Biodiversity & Ecosystem Services

CSA: Climate Services and Adaptation

ESF: Empower Sustainable Futures

LBM: Land Based Mitigation & Adaptation

NFE: Nutrients, Food, and Environment

WCF: Water, Climate, and Food

WQ: Water Quality

BES

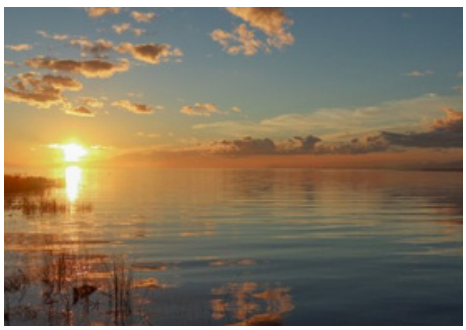
Biodiversity and Ecosystem Services

The BES team examines interactions within and between terrestrial, aquatic, coastal and marine ecosystems, the services they provide, the biodiversity they host and their effects on human-well-being.

Our research aim is twofold. First, we advance integrated approaches to quantify, model and/or map (changes in) biodiversity and ecosystem services, based on the understanding of underlying biological, socio-economic and geophysical mechanisms and landscape characteristics.

Second, we explore pathways towards sustainable futures, by investigating the role and potential of nature to solve, at least partly, several sustainability challenges in a simultaneous way. We examine trade-offs between policy and management targets and investigate solutions to minimize these trade-offs and enhance synergies.

Our research follows an integrative/system perspective and uses a variety of methods, that includes modelling, mapping and participatory approaches, at various spatial and temporal scales. Our research relies on a wide range of disciplines (e.g. ecology, hydrology, economics) and on close cooperation with societal stakeholders. We generate knowledge on effective ways to manage ecosystems, biodiversity and multiple ecosystem services to support healthy, sustainable and resilient socio-ecosystems.



CSA

Climate Services and Adaptation

Multiple sectors are increasingly aware how vulnerable our society is to the impacts of climate change. Following the rapid increase of monitoring of climate data there is a need to transform these into climate information services and adaptive planning. This includes ICT-tools, relevant products and aligned services such capacity building, education and networking to benefit society at all scales.

To achieve that, the human component needs also to be taken into account to deliver research-based, tailor-made water & climate information services.

ESF

Empower Sustainable Futures

The mission of the subgroup Empower Sustainable Futures is to empower society to transition towards sustainable futures in a changing global environment. We believe that empowering people to become more sustainable requires transdisciplinary and participatory methodologies, tools and approaches. They allow us to generate, communicate and implement new knowledge while fully taking into account the complexity of decision and policy challenges that societal actors face.

We actively engage society in scientific research, leveraging the power of citizen science and participatory approaches to address environmental and societal challenges. By collaborating with the public, we not only enrich its scientific knowledge base but also enable individuals to gain valuable knowledge and skills that can inform decision-making processes.

Recognizing the importance of inclusivity and diversity, we foster collaborative learning through co-creation, education, science communication and adaptive planning. By integrating non-expert knowledge and diverse stakeholder perspectives, we ensure equitable and just responses to climate change and other global changes. We contribute to a sustainable society, where science and society converge to drive meaningful progress. Participatory and transdisciplinary approaches are therefore the foundational core of the subgroup.

This main focus is operationalized through three distinct research areas:

- Scenarios and pathways
- Participatory knowledge creation and dissemination
- Education on sustainability

LBM

Land Based Mitigation and Adaptation

Water plays a vital role in land based mitigation and adaptation of climate change. Growth of natural vegetation and crops and soil organic matter decomposition are limited by water availability in many parts of the world, constraining the carbon sequestration potential of terrestrial ecosystems, both natural and agricultural.

In a major project we study the interaction between water management and greenhouse gas (GHG) emissions from organic soils in Dutch fen meadow landscapes. Evaporative cooling by vegetation can reduce local climate warming more directly, controlled by both the amount of vegetation and the water availability, making it a potential adaptation option. In multiple projects, we study the climate effects of land restoration efforts worldwide, both through the evaporation and GHG linkages. Adaptation to water and heat stress in crops also builds on the same expertise, and we use crop models to study the effect of especially climate variability to develop early warning systems and to contribute to more climate smart agriculture.

In this research theme we do observations of greenhouse gas emissions and energy partitioning, remote sensing based analysis of vegetation status and associated climate parameters, and data driven and process based modelling.

NFE

Nutrients, Food and Environment

Our vision is Sustainable agriculture for soil, water and air. Our ambitions are to:

- Perform research on understanding and modeling carbon, nutrient, and pollutant dynamics within agricultural ecosystems across varying scales.
- Educate BSc, MSc, and PhD students in linking food, water, soil and the environment.
- Collaborate with global research communities on agricultural ecosystem management.
- Inform relevant stakeholders in the agricultural sector (policy, farmer associations, supply chain) on sustainable farming practices and governance approaches.

Our research focuses on better understanding of the complex interactions between food production, soil quality, water availability, carbon and nutrient dynamics, and environmental impacts in response to agricultural management. To achieve this, we combine process-based/empirical modeling with data-driven insights from methods such as meta-analysis and machine learning. Our central research lines are:

- Food production in response to Nutrient and Water availability
- Interactions between Food Production and Soil health
- Interactions between Food Production and Environment

Our area of interests include: the Netherlands, Europe and China with high intensity agriculture (with priority on reducing environmental impacts while sustaining the food production), Africa (with low intensity agriculture with priority on food production) and global.

WCF

Water, Climate and Food

Sufficient water of good quality is crucial for people and the environment. Over the past decades water demand for human water uses more than tripled driven by population growth, socio-economic development, expansion of irrigated area, and climate change. Negative impacts of the overuse of water are already experienced for many regions of the world. Given the projected climate change, population growth, and socio-economic developments worldwide the pressure on our freshwater resources will continue to increase.

In the Water, Climate, Food subgroup we aim to better quantify the current and future availability of our freshwater resources and how much we can use in a sustainable way. We specifically focus on studying the impacts and trade-offs between water used for food, energy, and needed to maintain a healthy environment. In addition, we quantify the current and future dependency of crop production on sufficient water and how water scarcity or flooding will impact crop production and food security. Finally, we evaluate potential adaptation pathways to 'bend the trend' towards a more water and food secure world.

We use novel and unique numerical models at scales from global to regional. A specific aim of the regional-scale modelling is to ensure that scientific knowledge truly meets the needs in generating sustainable solutions and to make sure that management interventions will not have unwanted side-effects. Regions where our regional scale research is focussed on are, for example, Pakistan, India, and Bangladesh.

WQ

Water Quality

Our vision is: clean water for society and ecosystems, today and in the future.

Our research focuses on assessing water pollution hotspots, sources, impacts, and trends in time and space. We contribute to a better understanding of interactions between water quality, society and ecosystems. We identify synergetic interventions for water quality improvements across water bodies and scales. For this, we develop innovative modelling tools to assess water quality and impacts, and explore interventions.

We do this across four main research lines:

- Multiple Pollutants
- Human Health
- Lakes
- Water-food interactions

Our ambitions are:

- To contribute to the development of synergetic interventions to reduce water pollution and impacts on society and ecosystems across water bodies and scales under global change;
- To become an inspiring social subgroup where its members interact openly and have opportunities to develop their skills (e.g., leadership, communication);
- To educate BSc, MSc and PhD students in water quality knowledge and integrated approaches;
- To engage in (inter)national initiatives on water quality to support policy development;
- To advocate transition towards clean water futures globally.

Research projects
Subgroups

BES

CSA

ESF

LBM

NFE

WCF

WQ

5.1

Research projects

Biodiversity and Ecosystem Services (BES)

TRANSFORMATIVE Bioeconomies

Towards a materials transition
that phases out fossil feedstock

Research challenges

Phasing out fossil feedstock not only requires a transition towards renewable energy, but also a transition towards renewable materials. We need to develop new ways of producing the materials we use (plastics, textiles, building materials, etc.) and also device strategies to support and speed up this transition. The materials transition requires effective integration of knowledge from several fields. We aim to explore and support material transition, and strengthen the collaboration and coordination between scientists from widely diverging disciplines as well as between these scientists and societal stakeholders.

Methods

We focus on two sectors (textile and building material) and on four transition pathways (biobased materials, recycling, CO2 capture and utilization technologies, and dematerialization). We develop innovative methodologies, concepts, tools and modes of working that facilitate enhanced mutual understanding and integration of knowledge across disciplines. We explore, develop and test novel solutions and principles that have a potential to contribute to the materials transition. We work primarily in the sectors of textiles and building materials, but the methods and principles developed are geared to having a wider relevance. We facilitate collaboration between different stakeholders. We contribute to understanding of collaborative approaches work best to facilitate the materials transition. We set approaches to support material transition in transdisciplinary projects.

Results (expected)

Expected results include i) funding of several projects, such as Wild card projects, and ii) development of sets of methods to support pluri- or trans-disciplinary collaboration in the field of sustainable transitions.

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IDeas

Tejiendo paisajes sostenibles

IDEAS : Research and development for the stabilization of the agricultural frontier

Research challenges

Stabilizing the agricultural frontier requires agro-ecological intensification, forest management and restoration, and improvements in territorial governance systems. In post-conflict Colombian territories, the gap between agricultural innovations and territorial planning is large. We follow an integrative landscape-level approach to (i) maximize positive benefits of ecological interactions between landscape components for ecosystem services essential for agro-ecological intensification, (ii) enhance socio-economic complementarities between agricultural innovation, forest management and restoration strategies.

Methods

The Project develops three components: governance strengthening, evaluation of performance of land uses and value chains at the landscape level, and design of sustainable territories. We have developed a geographic platform that allows modeling use scenarios and defining one or more scenarios agreed with stakeholders. This will enable the characterization of more optimal scenarios at the landscape scale.

Results (expected)

(i) Governance arrangements identified and implemented to strengthen synergies between stakeholders and institutions; (ii) consolidation of a shared vision of the territory for the closure and stabilization of the agricultural frontier; (iii) ecosystem services, and landscape transformation process characterized and incorporated in an integrated way by the different stakeholders in their practices; (iv) concerted territorial management scenarios and action plans aimed to the closure and stabilization of the agricultural frontier and the sustainable use of forests; (iv) public policy recommendations based in the characterized agricultural and forestry value chains and value networks.

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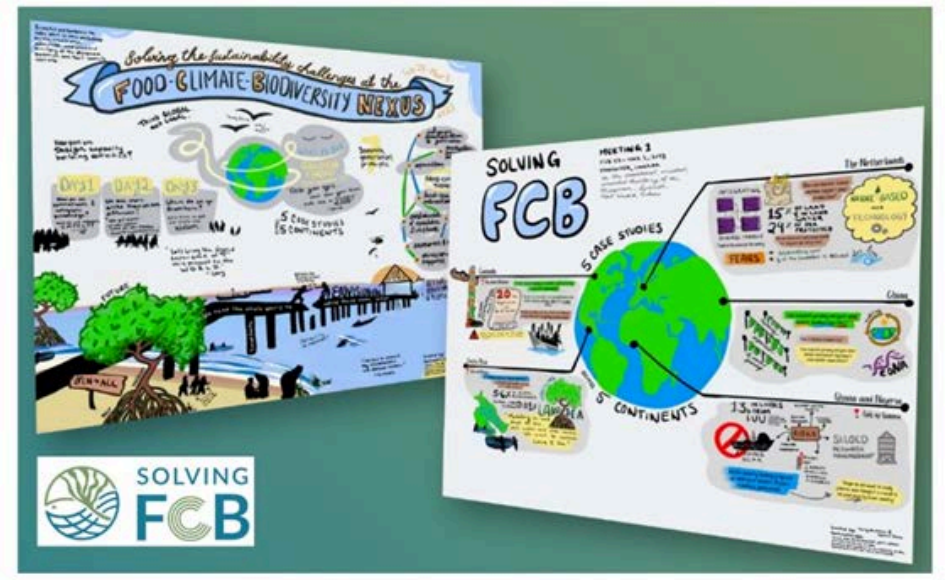
Solving the Sustainability Challenges at the FCB Nexus



Research challenges

To ensure a sustainable and secure future for both humans and the natural environment, decisions about natural resource use and societal well-being must be aligned with Earth's environmental limits. The major global challenge of finding a just, equitable and culturally-sensitive way to feed and nourish the future human population while achieving biodiversity conservation and climate mitigation goals is the focus of this expert panel. The “Solving the Sustainability Challenges at the Food-Climate-Biodiversity Nexus” (Solving-FCB) partnership aims to support and facilitate the development of viable FCB solutions that explicitly consider their complex social and ecological contexts. In The Netherlands, the Partnership aims to explore nexus-informed pathways towards circular and ‘nature inclusive’ food systems.

Methods

The Partnership is grounded on five case studies that focus on FCB challenges under a range of societal and environmental contexts. We will use both qualitative and quantitative methods to analyse relationships and feedback in FCB systems, including integrated modelling and scenarios development to evaluate temporal and spatial dynamics and impacts in response to FCB-related actions, and co-production of knowledge with stakeholders and rights-holders.

Results (expected)

For the Dutch case study, we expect the following results:
Representation of plausible futures of ‘nature-inclusive’ food systems; Guidance to policy-makers and stakeholders on socioeconomic and/or policy transitions; Application of the nexus approach to solve FCB challenges in well-developed economies.

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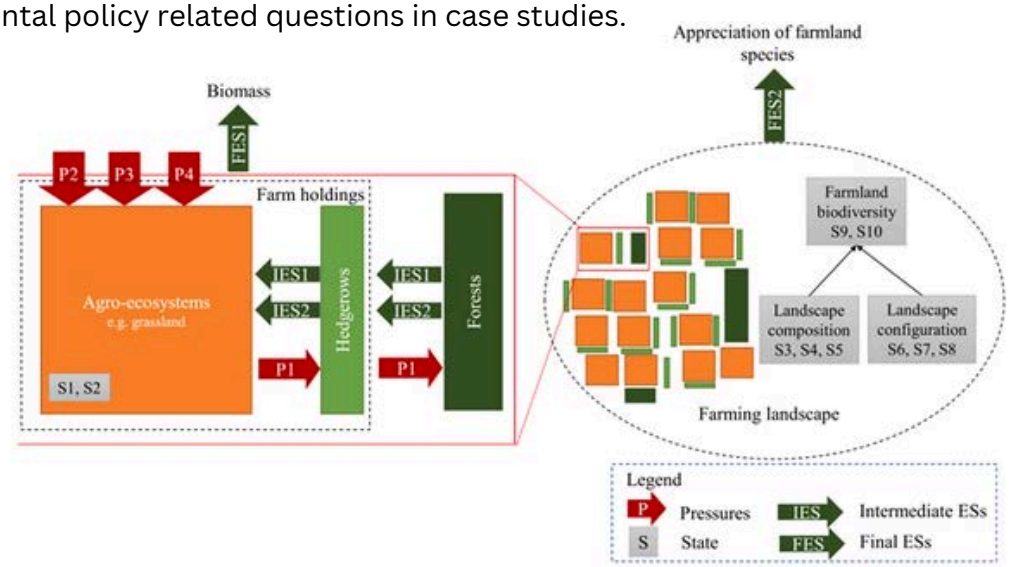
Applying ecosystem accounting to support agro-environmental policy policies

Research challenges

Impacts of agriculture on farmland biodiversity and ecosystems increasingly concern society, and transitioning towards a nature inclusive agriculture has become a policy priority. To monitor progress towards this priority, the interdependencies between agricultural activities and ecosystems must be assessed and monitored. Ecosystem accounting which organizes data on ecosystems and their services and link these data to economic activities could address this need. Therefore this research aims to determine how ecosystem accounts should be designed so that they can help monitoring agro-environmental policies in the Netherlands and the European Union.

Methods

This research project aims to assess the potential use of the System of Environmental Economic Accounting Ecosystem Accounting (SEEA EA} framework for agro-environmental policies. Starting from the analysis of the alignment of the current SEEA EA framework with agro-environmental policy needs, propositions to better adapt the framework for this purpose are developed and tested on agro-environmental policy related questions in case studies.



Results (expected)

- The Dutch SEEA EA accounts have a potential to strongly enhance the CAP monitoring and evaluation framework;
- However, further steps need to be taken, such as integrating information on farming emissions (externalities) and evaluating the applicability of SEEA EA accounts for case studies at landscape and farm scales;
- The Dutch SEEA EA ecosystem extent accounts can support the analysis of how landscape composition and structure influences the effectiveness of agri-environmental measures aimed at enhancing farmland biodiversity.

Publications

Grondard, N., Hein, L., Van Bussel, L.G.J., 2021. Ecosystem accounting to support the Common Agricultural Policy. Ecol. Indic. 131, 108157.

Grondard, N., Kleyheeg, E., Hein, L., Van Bussel, L.G.J., 2023. Effects of Dutch agri-environmental field margins and bird plots on cropland birds. Agriculture, Ecosystems & Environment 349.

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Mainstreaming Ecological Restoration of freshwater-related ecosystems in a Landscape context: INnovation, upscaling and transformation (MERLIN)

Research challenges

MERLIN identifies landscapes with high potential and priority for transformative restoration, particularly focusing on essential ecosystem services, biodiversity targets, and climate change mitigation and adaptation. MERLIN illustrates environmental value chains as well as costs and benefits of Nature-based Solutions for selected European regions. This economic analysis demonstrates the opportunities for green business resulting from transformative restoration.
In MERLIN, we support hydrological modeling, environmental costs and benefits analysis and the development of financing solutions for the upscaling of freshwater-related ecosystems restoration.

Methods

Hydrological modelling, Natural Capital Accounting and Cost Benefit Analysis

Results (expected)

Demonstration of environmental costs and benefits analysis of freshwater ecosystems restoration in five water catchments.

involved in the project:

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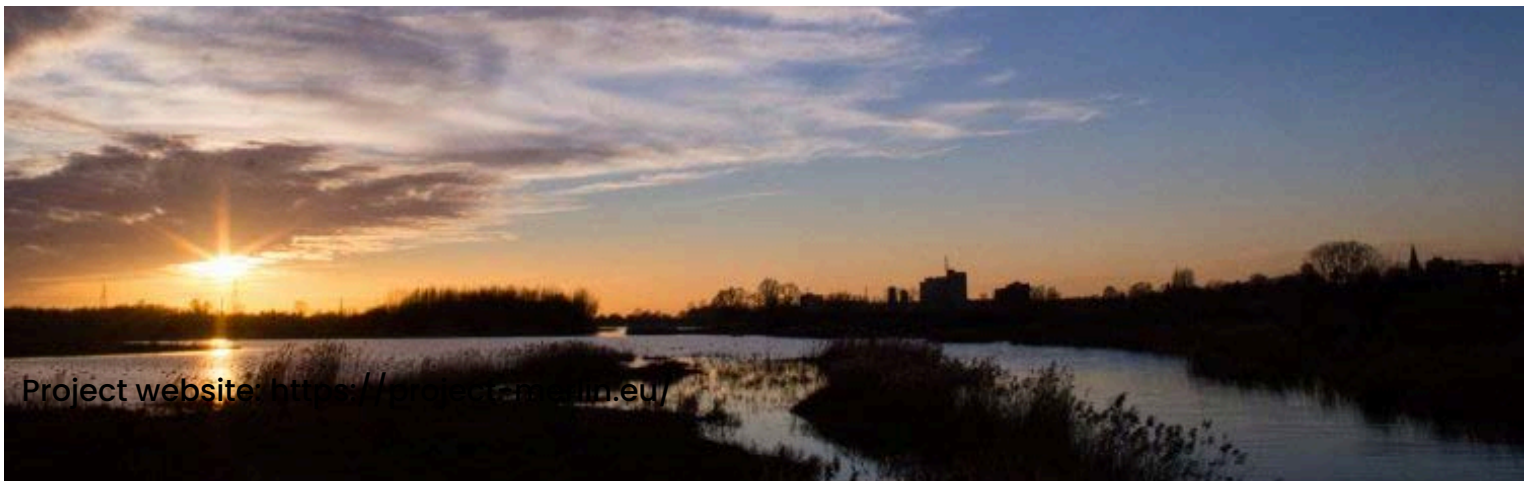

Project website: https://projectmerlin.eu/





SCIENCE FOR EVIDENCE-BASED AND SUSTAINABLE DECISIONS ABOUT NATURAL CAPITAL (SELINA)

Research challenges

SELINA aims to provide guidance for evidence-based decision-making that supports the protection, restoration, and sustainable use of our environment. SELINA will set new standards for international cooperation to promote Ecosystem Services (ES) and Biodiversity (BD) conservation and enhance Ecosystem Conditions (EC).

In SELINA, WU is leading WP5 on Ecosystem Accounting. WP5 aims to assess (1) how ecosystem disservices and negative externalities can be integrated to the ecosystem accounting framework, (2) demonstrate the use of earth observation data to support ecosystem accounting and (3) assess implications of using different value assumptions in monetary valuation.

Methods

The System of Environmental Economic Accounting – Ecosystem Accounting (SEEA-EA) is developed under auspices of the UN Statistical Commission. It provides a consistent framework for analysing and storing information on ecosystem assets and flows of ecosystem services. The SEEA is part of the System of National Accounts, used by statistical agencies world-wide for the production of economic and other statistics.

Results (expected)

Demonstration of how ecosystem disservices and negative externalities can be integrated to the ecosystem accounting framework. Demonstration of the use of earth observation data to support ecosystem accounting. Assessment of scientific and policy implications of using different value assumptions in monetary valuation.

Involved in the project

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Project webpage: https://www.project-selina.eu/





Biodiversity modeling for accounting and monitoring

Research challenges

Biodiversity plays a crucial role in a healthy planet and its inhabitants, yet anthropogenic pressures have led to biodiversity degradation, especially in the tropics. Effective policy-making and conservation efforts require indicators that can accurately measure and monitor biodiversity, however, existing indicators have limitations including spatiotemporal explicity, resolution and extent, reliability in data-scarce regions, and lack of consideration for varying ecological significance in different ecosystem types, species and local contexts. Recent advancements in satellite remote sensing, data infrastructure and artificial intelligence have provided novel opportunities for data-driven high-resolution biodiversity modeling approaches across large spatial and temporal scales. Thus, this PhD research aims to develop reliable indicators and workflows to measure and monitor biodiversity using remote sensing and machine learning in the Netherlands (data-rich country) and the Amazon forest (data-scarce region).

Methods

1.Literature review;
2.Identifying ecologically valid indicators and developing their prediction models for the Netherlands;
3.Developing indicators for the Amazon forest using species distribution models;
Developing a workflow to compute temporal changes of biodiversity in the Amazon forest.

Results (expected)

Indicators, models and maps of biodiversity for accounting and monitoring in the Netherlands and the Amazon forest.

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Waterveiligheidlandschappen (Future Proof Landscapes)

Research challenges

In this project we explore an integrated climate adaptation approach for the Frisian Wadden Sea Coast and the Riverine area near Arnhem (Splitsingspunt) in close collaboration with stakeholders. We aim to look beyond measures like reinforcement of dikes and include the potential of the entire landscape in our search for long-term adaptations.

We analyze the impact and effectiveness of 3 Nature-based Solutions by modelling and GIS. These NBS will contribute to a future-proof (i.e. a flood and drought resistant) landscape, that we will visualize to aid communication with a broad range of stakeholders.

Marc Meijer focuses on the tool 'Tangible Landscape', and develops a set-up that can be used during stakeholder sessions.

Methods

We analyzed (together with the other project partners) recent adaptation and flood protection projects, and participate in sessions to design future-proof water systems. We explore the impact and effectiveness of several NBS by modelling and GIS analysis.

Furthermore, we define the requirements of Tangible Landscape as a supportive tool.

Results (expected)

We use insight on the strengths and weaknesses of recent adaptation projects for the development of climate adaptation horizons for the cases. We develop a set of data on impact of 3 NBS in the coastal and riverine landscape.

In our subproject we provide recommendations on existing and promising applications of TL.

Publications

Klostermann et al. 2023. Waterveiligheidslandschappen; Syntheserapport Voorbeeldprojecten. Syntheserapport-voorbeeldprojecten.pdf (waterveiligheidslandschappen.nl)

Meijer, M., van Lammeren, R. J. A., & van Buuren, M. (2021). Tangible Landscape: A Waterway Design Education Tool. Journal of Digital Landscape Architecture, 6, 487-494.

Meijer, 2024. Manual for the application of a GIS-based tool to design Future-proof Landscapes.

In this TKI project we collaborate with WENR, Deltares, Waterschap Rijn en IJssel, Reframing Studio, Royal HaskoningDHV, SWECO, LAOS Landschapsarchitecten, Fryske Gea, Provincie Noord-Holland, Gemeente Den Helder, Waterschap Rivierenland, Provincie Gelderland, Provincie Fryslan, Wetterskip Fryslân en Hoogheemraadschap Hollands Noorderkwartier.

https://waterveiligheidslandschappen.nl/

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Waterveiligheids landschappen

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EU H2020 Green Deal REST-COAST

Research challenges

To explore how upscaled coastal restoration can provide a low-carbon adaptation, reducing risks and providing gains in biodiversity for vulnerable coastal ecosystems, such as wetlands or sea grass beds. By overcoming present technical, economic, governance and social barriers to restoration upscaling, REST-COAST will develop the large-scale river coast connectivity and increase nearshore accommodation space for the resilient delivery of coastal ecosystem services.

Methods

We analyze NBS pilots in the Ems-Dollard estuary to identify smaller and more homogeneous units and to gain insight in the geomorphological, ecological and socio-economic boundary conditions of NBS.

Results (expected)

A systematic downscaling approach to define NBS as building blocks of large scale restoration.

We collaborate with Universitat Politecnica de Catalunya (lead), Global Climate Forum, Deltares, Helmholtz-Zentrum, Provincie Groningen, University of Lincoln, University of East Anglia, Stichting Ecoshape, Stichting the Global Center on Adaptation, Wageningen Marine Research, and several others.
For more information: REST-COAST

REST-COAST

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Living Lab in the Dutch Delta: Hedwige-Prosperpolder

Research challenges

The objective of our subproject in this NWO 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. Although managed realignment will result in the restoration of salt marsh foreland, it may also come with trade-offs due to the deposit of wrack (dead plant material). This can affect the quality of the dike grass cover and also may impact the Blue Carbon capacity of the system.

Methods

The dikes of hybrid flood defences were researched in four studies that ranged from a European scale, to a fieldsite in the Netherlands and a lab experiment.

Results (expected)

One of our results was that dikes can be adapted in such a way they facilitate integration with vegetated foreshores into a hybrid flood defence.

Publications

- Van den Hoven et al. 2024. Greening the dike revetment with historic sod transplantation technique in a living lab. https://doi.org/10.1111/jfr3.12968.
- Van den Hoven et al. (2023). How natural foreshores offer flood protection during dike breaches: An explorative flume study. Estuarine, Coastal and Shelf Science https://doi.org/10.1016/j.ecss.2023.108560
- van den Hoven, K., Kroeze, C. and van Loon-Steensma, J.M., (2022). Characteristics of realigned dikes in coastal Europe: Overview and opportunities for nature-based flood protection. Ocean & Coastal Management, online first https://doi.org/10.1016/j.ocecoaman.2022.106116
- Van den Hoven, K., Kroeze, C., van Loon-Steensma, J.M., 2021. How about the dikes? Managed realignment in progress at the Hedwige-Prosperpolder. In: Proceedings of FLOODrisk 2020 - 4th European Conference on Flood Risk Management. https://doi.org/10.3311/FloodRisk2020.14.13

In this NWO project we collaborated with TU Delft, NIOZ and HZ, and with the InterReg project Polders2C's (Living Lab Hedwige-Prosperpolder | Polder2C (polder2cs.eu))

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Living with Water

Research challenges

This research project aims to help communities on British Columbia's South Coast prepare and adapt for sea level rise and flooding.
Climate change projections show BC's South Coast, including the Fraser River Delta, Burrard Inlet and Squamish Delta, could be facing sea level rise of up to one metre in the next eight decades as well as increased flood scale and frequency—with resulting risks to residents, critical infrastructures, food security, and biodiversity.

Methods

MSc studies on e.g. adaptation options, suitable Nature Based Solution (NBS) approaches, adaptation agreements.

Results (expected)

Examples and advices on suitable NBS and adaptation options

In this Pacific Institute for Climate Solutions (PICS) project we participate with University of British Columbia (UBC) (lead) and Simon Fraser University, University of Waterloo, and West Coast Environmental Law, and several Canadian local solution seekers (e.g. municipalities, NGO's and local communities).
Coastal Adaptation: Living with Water | PICS (uvic.ca)

PICS
PACIFIC INSTITUTE
FOR CLIMATE SOLUTIONS

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EU H2020 Green Deal: WaterLANDS

Research challenges

WaterLANDS: Water based solutions for carbon storage, people and wilderness. This European project aims to restore European wetlands – including coastal wetlands – together with surrounding communities. Due to changes in land use, many species of plants and animals, as well as hidden ecosystem services such as retention of water and carbon and natural coastal adaptation, have disappeared from the landscape. Consequences of these changes are increased flooding, soil subsidence and deteriorated water quality. WaterLANDS aims to bring together best practices from fragmented restoration projects across Europe in order to define solutions that benefit both environment and people. The best practices will be tested by restoring wetlands, including coastal marshes.

Methods

One of the restoration action sites is the Ems-Dollard estuary, where already several nature based adaptations are implemented. Research activities within

WaterLANDS have to be aligned with the ambitions of the Eems Dollard 2050 program.

Results (expected)

Advice on implementation and impact of coastal NBSs

Wageningen partners are dr. Juul Limpens, dr. Milena Holmgren, Prof. Francisco Alpizar Rodriguez.
See: www.waterlands.eu/

Dr. Ir. Jantsje van Loon-Steensma
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WaterLANDS

Realization of ecological values along coastal and freshwater systems in relation to contracting.

Research challenges

This Engineering Doctorate project focuses on the realization of large infrastructural technical watersafety projects along the coasts and along the rivers, in relation to contracting. The research challenge is to design an accessible framework to include measures for nature in a project.

Methods

Contracts are awarded based on a combination of price (quantity) and quality. In the quality part the contractors are challenged to include extra measures for nature. They can earn points by this, which results in a fictive reduction of the financial bid. This enlarges the chance to win the tender of the project. An example of this tendering procedure is the Afsluitdijk project. Currently the Afsluitdijk is renovated and reinforced and an ecological dike is realized. On the talud on the Wadden Sea site Levvel blocs were placed with a roughened toplayer and two holes. These blocks function in the tidal zone, as habitat, for seaweed, mussels and butterfish. The second aspect of the ecological dike is the reintroduction of the special rocky coastal vegetation with rare species for the Netherlands like Wild cabbage and Sea pea. As third aspect a herb rich grass vegetation was sown on the crown and inner slope of the dike.

Results (expected)

The result of my research is a design or framework which makes it more accessible to include measures for nature in infrastructural technical watersafety projects along the coasts and along the rivers.

This is an Engineering Doctorate project with a design as the final product.

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Nature Based Solutions as Building Blocks for Upscaling Coastal Adaptation

Research challenges

Nature Based Solutions (NBS) are experimental and site-specific due to complex biophysical, geographical, morphological and socio-economical interactions in each NBS implementation site. So, developing generic standards and norms for the best NBS practices is extremely challenging.

We explore the potential of a novel NBS Building Blocks Framework that will contribute to the transdisciplinary decision-making processes with new knowledge and tools. Thus, the Framework will be used in identifying most effective NBS for upscaling coastal restoration as an effective climate adaptation strategy from a more biodiversity- and ecosystems-based perspective.

Methods

- Co-creation of the conceptual framework for NBS Building Blocks
- Co-implementation of the framework at case study sites: Bilateral Pilot Workshops (H2020 EU Green Deal REST-COAST)
- Testing the framework beyond EU: Case Study in Gediz Delta, Turkey

Results (expected)

Inventory of NBS Building Blocks as Coastal Restoration Units at specific delineations along several European pilot sites. These Building Blocks link the biophysical and socio-economic parameters at the implementation site to the expected Ecosystem Services improvements and Biodiversity gains. These inventory of Building Blocks are the basis for upscaling coastal restoration.

Publications

C. Arslan & J. van Loon-Steensma, in prep., Nature Based Building Blocks Approach for Upscaling Coastal Nature Based Solutions

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Nature-based solutions to protect against floods and droughts: Comparison between Thailand and Western Europe

Research challenges

Although researchers worldwide have increasingly focused on nature-based solutions (NBS), there remains a notable gap in our understanding of how NBS function and the benefits they offer in terms of co-benefits to the local environment. Moreover, there is a scarcity of case studies in Asia, particularly in Southeast Asia, despite the area's abundant biodiversity. This makes it a prime location for examining NBS and establishing a model for other nearby regions to emulate.

Methods

The project is comprised of multiple phases. The initial phase requires conducting a thorough literature review to gain a comprehensive understanding of the various approaches to NBS implemented across different countries. The subsequent phase involves analyzing the performance of NBS that have already been implemented in the Netherlands and Europe to identify any disparities from the original design stage, utilizing GIS or other methodologies. The concluding phase entails adapting an NBS model and implementing it in a pilot location in Thailand to advance its promotion, and to evaluate its efficacy when applied to alternative settings.

Results (expected)

Studying successful cases of Nature-Based Solutions (NBS) implementation globally can provide valuable insights on how to effectively maintain them. This knowledge can be utilized to scale up NBS as a viable option during construction to mitigate the risks posed by meteorological events that are increasingly common due to climate change. With the help of NBS, we can ensure a safer living environment without sacrificing the benefits of nature.

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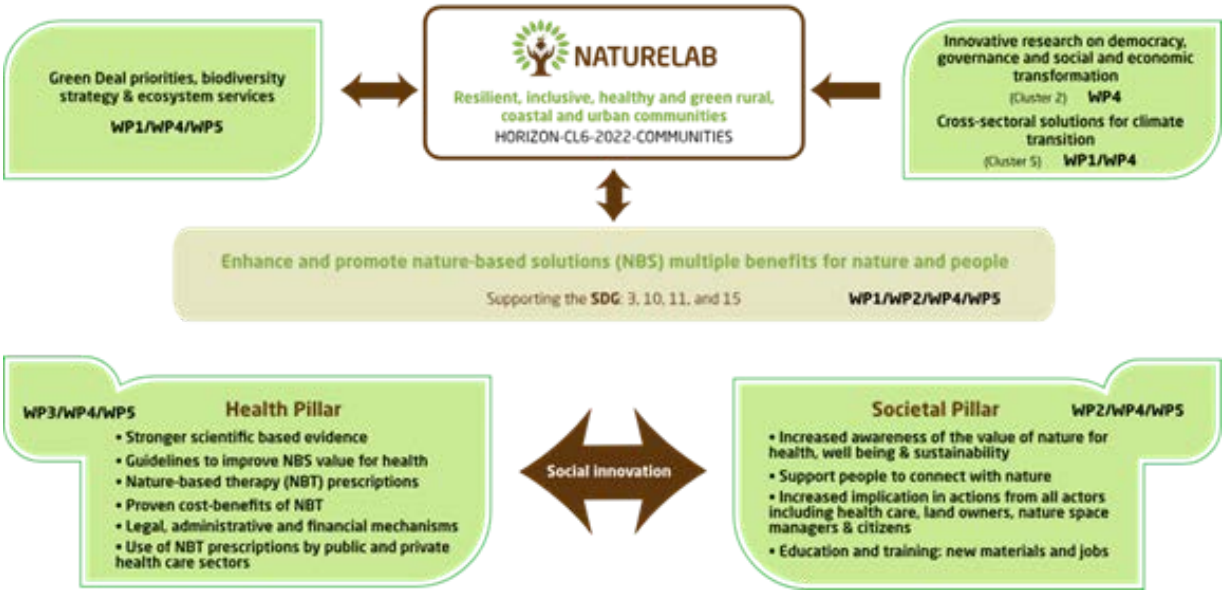
NATURELAB

Nature based interventions for improving health and well-being (NATURELAB)

Research challenges

Nature spaces remain poorly recognized, promoted and used as care providers. Nature-based therapies (NBT), however, can promote well-being and support health prevention and rehabilitation. The challenge is to develop and establish scientifically validated programs to support people to connect with nature in a way that responds to their specific personal needs.

Methods



Results (expected)

The expected outcomes of NATURELAB are: (1) nature-based therapy programs adjusted to different population needs; (2) portfolio to classify nature's healing potential & specific guidelines to analyze the health benefits provided by nature spaces; (3) guidelines for the development and maintenance of nature spaces that can provide climate resilience and environmental sustainability; (4) program guide for financing strategies to support NBT; and (5) guidelines to promote the integration of NBT care in the health sector.

The project aims for 600 health professionals worldwide to receive the NATURELAB NBT programs, deliver innovative educational and training materials, and explore the potential of new jobs, such as therapists, and in horticulture & gardening industries.

https://naturelab-project.eu/resources/#publications

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Natural Capital Accounting, the Netherlands

Research challenges

Natural vegetation contributes to the well-being of people. But in many policy and business decisions, economic interests take precedence over nature, disregarding the contribution and value of nature to human welfare and well-being. Resulting in unsustainable use of natural resources and ecosystem degradation. With the Natural capital accounts we aim to 1) map the relationship between nature, economy and human activities and 2) show trends in stocks and flows of natural resources in a clear and internationally comparable manner, 3) inform policy and business to make sustainable choices.

Methods

In the Natural capital accounting project we used the System of Environmental Economic Accounting – Experimental Ecosystem Accounting (SEEA-EEA) as the methodological basis. The SEEA EA is developed under auspices of the UN Statistical Commission. It provides a consistent framework for analyzing and reporting information on ecosystem assets and flows of ecosystem services.

A key aspect of the SEEA EA is that it takes a spatial approach to accounting. In the SEEA EA Ecosystem accounts are presented using maps (integrating geographical, environmental, ecological, and economic information) as well as tables.

Workshops are conducted with stakeholders for a better connection with policy applications.

Results (expected)

The Natural capital accounts for the Netherlands have been developed for each year from 2013 to 2021, and will be updated annually.

More information:

This research was funded by the Ministry of Agriculture, Nature and Food Quality (LNV) and was carried out in collaboration with Statistics Netherlands (CBS).

https://www.cbs.nl/nl-nl/maatschappij/natuur-en-milieu/natuurlijk-kapitaal

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SustainPalm

Enhancing Palm Oil Sustainability & Circularity

Research challenges

The issues on deforestations, biodiversity loss, and smallholders' income are become the major aspect to be solved in fostering sustainable oil palm and palm oil production in Indonesia. This oil palm sector involves various stakeholders with different interests and perspective, which define the management practices and its impact to the environment. The SustainPalm Programme was designed to bring the knowledge and partnership in the implementations of plausible solutions to address sustainability issues and increase the circularity of oil palm production, particularly in Indonesia.

Methods

The programme develops three Work Packages: (1) Increasing land value, (2) Circular and efficient biomass use, and (3) Carbon and biodiversity. The programme employs: (1) **living labs approach** to implement best practices and form examples for scaling up; and (2) **communities of practices** to facilitate learning of good practices, search for structural solutions, and form a network of parties inside and beyond the program interventions.

Results (expected)

(i) Consolidation of shared knowledge, understanding, and experience on the multiple socio-economics and environmental benefits

(ii) Establishment of plausible business models from oil palm intercropping, cattle integration, alternative use of palm and palm oil residue, and paludiculture

(iii) Policy recommendation targeted the improvement of palm oil and oil palm management practice based

Other information

This programe funded by the Dutch Government with Wageningen University and Research, Van Hall Larenstein University of Applied Science, Bogor Agricultural University and Lambung Mangkurat University as the main implementation partners and the Indonesian Coordinator Ministry for Economic Affair as the most important stakeholders to be addressed.

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Nature Positive Project

Research challenges

The nature-positive aspect of oil palm production presents a complex research challenge, particularly in addressing the significant gaps related to biodiversity and carbon sequestration. While oil palm cultivation contributes to economic development, the expansion has often been associated with biodiversity loss and increased carbon emissions. Hence, it is essential to bridge the gap in understanding the intricate relationships between oil palm cultivation, biodiversity, and carbon sequestration for devising effective strategies that promote a nature-positive approach.

Methods

This project employs several methods to (1) estimate and map biomass and carbon, and (2) quantify and map biodiversity that support the landscape integrity. As the project location involve community area, it will also involve methods to facilitate the engagement with various stakeholders, to analyze the current policy land use management, and to refine related policies.

Results (expected)

Representation on the contribution of nature and biodiversity to oil palm production. This includes biomass and carbon account (based on IPCC tier 2 and tier 3) and biodiversity account (focusing on pollination, pest control, and soil health)

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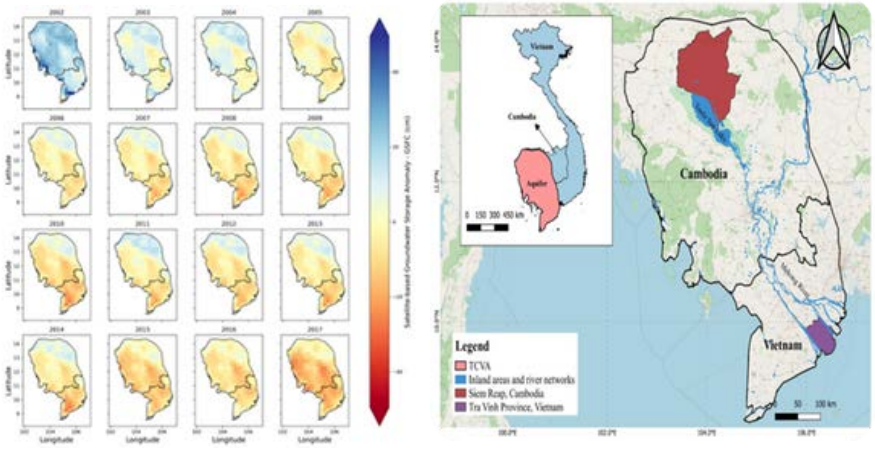

Ecosystem-based Adaptations for Sustainable Groundwater Resources Management (GEBA)

Research challenges

In essence, project GEBA targets the transformative changes in planning and decision-making processes in the management of TCVA, one of the most important Transboundary Aquifer (TBAs) in Asia. We do so by leveraging and mainstreaming EbA into plans, policies, and management practices in groundwater management at local, sub-national, and transnational levels. The project team, henceforth, adopts a two-dimensional-scaling approach simultaneously targeting horizontal and vertical scaling.

Methods

- The project ensures an integrated assessment of the groundwater resources in the transboundary Cambodia Mekong River Delta aquifer. It targets transformative changes in planning and decision-making processes in the management of the aquifer.
- The project included three work packages:
- 1.Quantify spatio-temporal trends in groundwater storage using remotely sensed products.
- 2.Evaluate the relative relevance of potential natural and anthropogenic stressors through intensive literature review and preparation of questionnaires for field surveys
- 3.Assess potential improvements from the application of different EbA measures in two provinces, Siem Reap in Cambodia, and Tra Vinh in Vietnam

Results (expected)

Siem Reap Province

Observation well	Rate of Depletion or augmentation of GW level (cm/yr)	District
DWP N2	30.36**	Puok
DWP N3	--	Puok
DWP N4	-33.96*	Puok
DWP N5	-52.56*	Angkor Thum
DWP N6	-28.32*	Siem Reab
DWP N7	-41.88*	Soutr Nikom
DWP N8	--	Soutr Nikom
DWP N9	--	Chi Kraeng
DWP N10	-38.28*	Soutr Nikom
DWP N12	--	Soutr Nikom

Tra Vinh Province

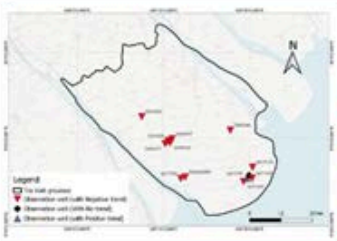

Fig: Trend of change in groundwater level

Observation well	Rate of depletion of GW level (cm/year)	District
Q07701A	-1.800*	Duyen Hai
Q07701H	---	Duyen Hai
Q217010	2.880**	Duyen Hai
Q404020	-29.400*	Tra Cu
Q40403T	-33.120*	Tra Cu
Q217020	-29.400*	Duyen Hai
Q217030	-32.040*	Duyen Hai
Q40403Z	-33.960*	Tra Cu
Q406040	-67.560*	Cu Ngang
Q217040	-27.360*	Duyen Hai
Q40404T	-41.160*	Tra Cu

More information

Project website: https://nbs4asia.com/ecosystem-based-adaptations-for-sustainable-groundwater-resources-management-geba/

Publications

1. Two policy briefs prepared for two case studies.
2. One abstract was presented at AGU, in 2022.
3. Two master's theses have been completed.
4. 1 journal article published

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Safeguarding Regional Food Security under Climate Change impacts via mainstreaming NBS (NAFOS)

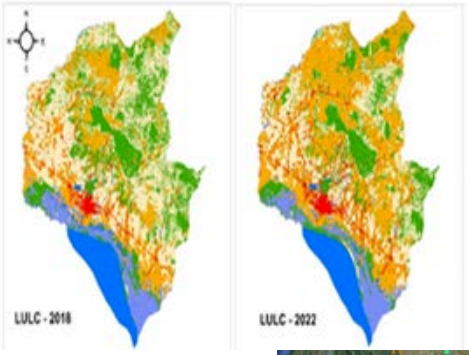
Research challenges

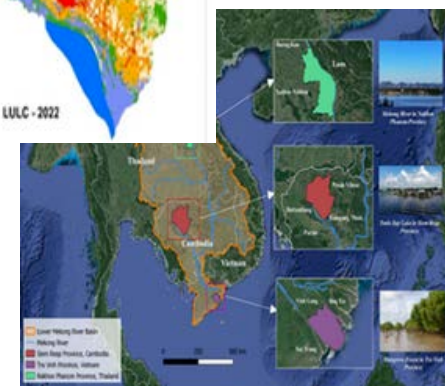
The Lower Mekong River Basin (LMRB) significantly safeguards the food security of geographically related countries, including Cambodia, Thailand, and Vietnam. However, millions of LMRB inhabitants are struggling to meet their dietary needs. Climate change (CC) even renders the basin even more food insecure via disrupted hydro-ecological regimes, intensified salinity intrusion, and deteriorated biodiversity albeit many structural and non-structural countermeasures implemented. There is, therefore, a dire need for innovative approaches to safeguard regional food security against climate change, and Nature-based Solutions (NBS) importantly represent one.

Methods

The planned activities planned are structured into 4 Work Packages (WP), including:

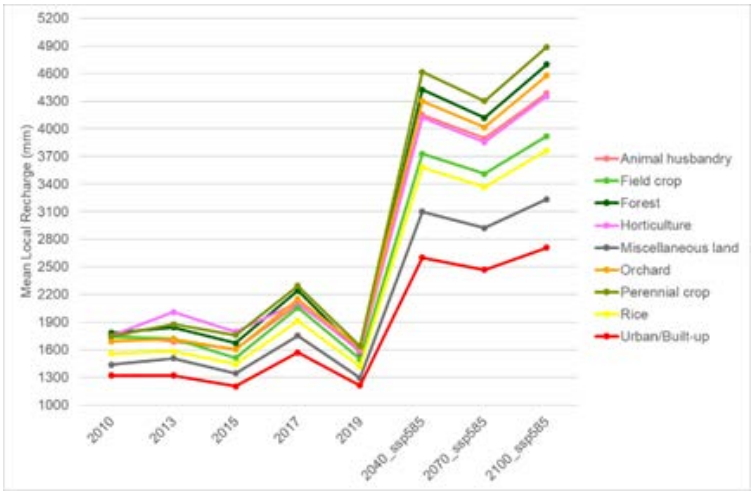
1. Evaluation of the climate change impacts on the ecosystem services (ES) that support food security.,
2. Curation of NBS best practices in safeguarding food security;
3. Assessment of the NBS potentials in enhancing LMRB's CC resilience and food security; and
4. Disseminating the research findings and building stakeholders' capacities via scientific publications, policy briefs, knowledge-sharing events, and social media products.

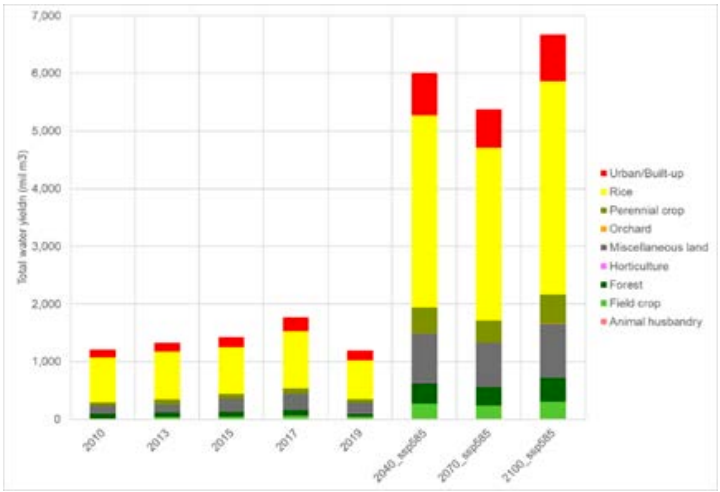




Results (expected)

Water Yield (i) and Recharge (ii) by Land Use Changes in Nakhon Phanom Province





Publications

1. One research manuscript under review in Heliyon.
2. One book chapter was submitted to Elsevier.
3. Two abstracts submitted to EGU 2024.

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Farmers, Citizens, and Free-range animals (Dutch: Boeren, Burgers en Buitenbeesten)

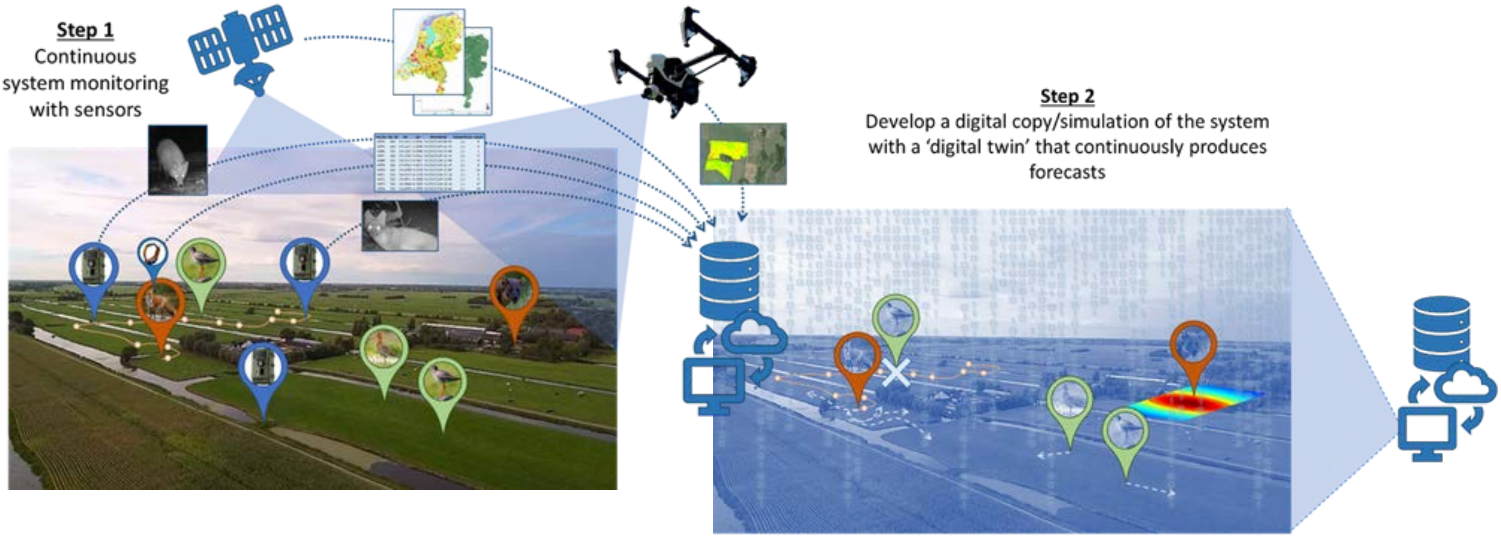
Research challenges

The number of meadow birds in the Netherlands continues to decline, despite years of efforts to protect them. Due to the current small meadow bird population, the focus is on predation pressure, which depends on:

1. Number of predators and potential prey in the breeding season
2. Site management and space use of all species throughout the year

To reduce the effect of predation pressure on meadow birds, the focus is currently mainly on predator control. However, more attention is needed on the effect of landscape management. This can be done by integral year-round management monitoring in combination with continuous data on the occurrence and behaviour of animals in the field, the quality of the habitat and management.

Methods



The monitoring data that is already collected is fragmented across different databases. Within this project, in collaboration with (national and international) managers and experts, work is being done to develop a prototype information system (i.e. Digital Twin) that integrates the available data streams from multiple sources and makes them applicable for managers.

Results (expected)

This project will deliver a prototype information system (Digital Twin) that integrates available data streams from multiple sources and makes them applicable for managers to inform biotope and population management choices in species protection in meadow bird areas in collaboration with end-users, managers, data collectors and system developers.

Project start date: July 2022
Project end date: June 2026
Project lead: Jelmer van Belle – Hogeschool van Hall Larenstein

Publications

de Koning, K., Broekhuijsen, J., Kühn, I., Ovaskainen, O., Taubert, F., Endresen, D., ... & Grimm, V. (2023). Digital twins: dynamic model-data fusion for ecology. Trends in Ecology & Evolution. https://doi.org/10.1016/j.tree.2023.04.010

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Nature FIRST – Biodiversity Monitoring and Forensics

Research challenges

The goal of Nature FIRST is to develop predictive, proactive and preventative capabilities for nature conservation stakeholders by combining theoretic premises from the sciences of ecology and environmental forensics with empirical environmental observations (satellite-based & on-site) into a Proof of Principle that is tested and demonstrated in 4 European areas, covering 6 biogeographical regions. To ensure that ecosystems are healthy, resilient to climate change and rich in biodiversity to keep delivering the essential range of services, we need better understanding of why and where biodiversity is declining and what the key triggers are.

Methods

We use a model-driven and continuous form of ecosystem monitoring. By assessing not only numbers of species and state, but also the modelled ecological and anthropogenic processes within an ecosystem, we are able to find cause-effect relations and improve our monitoring models based on retrofits and simulations to understand changes even better. We will make use of remote sensing & data science (e.g AI, semantics). To ensure that theory, models and practice reinforce each other, we use an iterative approach, including many demonstrations and field-tests to gain feedback and maximize impact.

Results (expected)

The models (Digital Twins), are a means for learning and the creation of context to translate environmental observations into facts and actionable information (intelligence) for site managers and policy makers. As almost all pressures on biodiversity are man-induced, we combine the domains of ecology and forensic science. This novel approach gives us access to robust scientific methods to detect and recognise (traces of) human (illegal) activities that negatively affect the environment.

Other information

Sep 1, 2022 - Aug 31, 2025

Partners:

Sensing Clues, Wildlife Forensic Academy, Staffordshire University, WWF (Romania and Ukraine), 3eData, Semantic Web Company, DotSPACE, Sustainable Scale-Up Foundation, Danube Delta National Institute, Bulgarian Academy of Sciences.

https://www.naturefirst.info/

Publications

Digital twins: dynamic model-data fusion for ecology.

https://www.cell.com/trends/ecology-evolution/fulltext/S0169-5347(23)00090-3

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Knowledge Hub on Bending the Curve of Biodiversity Loss

Research challenges

The decline of biodiversity is rapidly accelerating due to factors such as habitat loss, pollution, wildlife exploitation, and climate change, thereby jeopardizing the wellbeing of nature and humanity. Reversing this trend while managing trade-off, such as feeding a growing population, is a challenge that requires integrated approaches. The Knowledge Hub aims to identify such integrated approaches on global and regional levels through exploring scenario and model outcomes.

Methods

Building on the influential work of bending the curve of biodiversity loss (Leclère et al., 2020) the Bending the Curve Knowledge Hub aims to encourage networks of scientists and stakeholders to enrich current scenario thinking, addressing themes such as the impacts of climate change, the role of indigenous people in protecting biodiversity, or shifting consumption patterns.

The Hub will bring together experts, policymakers and stakeholders through workshops to define possible policy interventions, respective narratives and scenarios, and explore their implication for 'bending the curve' through an ensemble of integrated and biodiversity models on the global and regional (Amazon region) scale.

Results (expected)

In addition to comprehensive scenarios and model outputs that showcase the potential of different policy interventions for bending the curve of biodiversity loss, the project will also result in a well-functioning knowledge hub with a wide network of stakeholders who collaborate on the bending the curve work globally and regionally.

Publications

Leclère, D., Obersteiner, M., Barrett, M., Butchart, S. H., Chaudhary, A., De Palma, A., ... & Young, L. (2020). Bending the curve of terrestrial biodiversity needs an integrated strategy. Nature, 585(7826), 551-556.
Bending the curve of terrestrial biodiversity needs an integrated strategy | Nature

The Knowledge Hub is a collaboration between WUR, Utrecht University and WWF-NL. The website will be launched in the spring of 2024.

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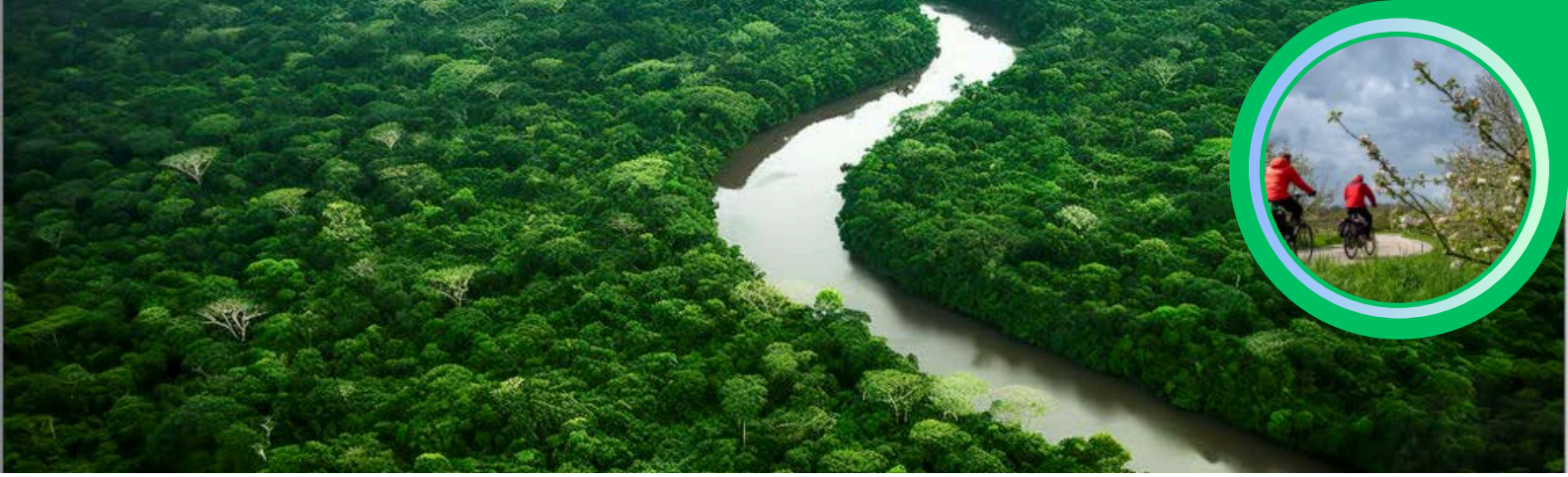

Understanding the nexus land use-biodiversity-ecosystem services

Research challenges

This study examines the repercussions of land-use change and climate change on the country's agriculture and ecosystem services, as well as explores the methodologies that can connect ecosystem services, sustainable agriculture management, and environmental policies.

Methods

Literature review, modelling, ecosystem services accounting methods

Results (expected)

- Impact of deforestation for rainfall patterns, and subsequently crop production in the last decade
- Combined effects of deforestation and climate change for crop production
- Applicability of SEEA EA ecosystem services accounting framework at the farm-level
- Framework for integrating farm-level ecosystem accounting into policies

Publications

Deforestation-induced changes in rainfall decrease soybean-maize yields in Brazil – Research@WUR

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Fabiana de Souza Batista (PhD)
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Development of a machine learning approach to analyse hydrological ecosystem services for ecosystem accounting.

Research challenges

Hydrological ecosystem services are among the most important services that ecosystems provide to society. It is therefore crucial that these services are included in natural capital accounts. However, to date, a clear conceptualization of hydrological ecosystem services for natural capital accounting, is still lacking. Moreover, existing hydrological models are very specific in terms of the data needed, and therefore not scalable to other watersheds. This makes scaling up these models wall-to-wall at a national scale (as is required for accounting) very difficult. This PhD research project will develop and test hydrological ecosystem services models compatible with natural capital accounting approaches in watersheds in Europe and Brazil.

Methods

Use a deep Learning model to predict surface runoff and streamflow within rivers using Convolutional LSTMS, weighted flow accumulation and LSTM cells.

Results (Expected)

The model will be a state-of-the-art spatially distributed machine learning algorithm that models the ecosystem's supply of these HES and captures the relation between the upstream and downstream parts of the catchment. Thereby, the model framework enables the evaluation and monitoring of these HES over time and can be used for running scenario analyses for different land-use changes.

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Application of Earth Observation (EO) for Ecosystem Accounting of the Forest Carbon

Research challenges

Ecosystem accounting systems like the UN-SEEA require spatially explicit information of carbon stocks and flows ideally every year and this requirement cannot be provided by relying on ground surveys alone. While EO maps can provide high spatial (e.g. hectare scale) and temporal (e.g. annual) resolution of carbon stocks and flows globally, they are not error-free and they need to undergo map assessment to evaluate map usability and even minimize map errors.

This EO-driven carbon accounts can be useful to countries and other stakeholders but this requires technical expertise and even cloud computing resources to compile.

Methods

Map assessment framework for minimizing map bias of forest carbon stocks and flows; Data-driven predictions of carbon fluxes; Development of user-friendly tools for Ecosystem Accounting using open source frameworks; Automated compilation of carbon accounts from EO dataset inputs

Results (expected)

Compilation and generation of carbon accounts including all carbon pools (above-ground, below-ground, soil, deadwood and litter) with reported uncertainties and anywhere in the world at any spatial level i.e. administrative or user-defined

Publications

- Araza, A., De Bruin, S., Herold, M., Quegan, S., Labriere, N., Rodriguez-Veiga, P., ... & Lucas, R. (2022). A comprehensive framework for assessing the accuracy and uncertainty of global above-ground biomass maps. Remote Sensing of Environment, 272, 112917.
- Araza, A., Herold, M., De Bruin, S., Ciais, P., Gibbs, D. A., Harris, N., ... & Hein, L. (2023). Past decade above-ground biomass change comparisons from four multi-temporal global maps. International Journal of Applied Earth Observation and Geoinformation, 118, 103274.
- Araza, A., De Bruin, S., Hein, L., & Herold, M. (2023). Spatial predictions and uncertainties of forest carbon fluxes for carbon accounting. Scientific Reports, 13(1), 12704.

Part of the work as postdoctoral researcher is to contribute to the Open Earth Monitor Project: Open-Earth-Monitor project – A cyberinfrastructure to accelerate uptake of environmental information (earthmonitor.org)

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Global modelling of biodiversity and ecosystem services for farming systems

Research challenges

This project aims to improve the land use modules of global models, in particular GLOBIO, by characterising agricultural systems with different diversity and intensity dimensions and estimating their associated biodiversity and ecosystem services. We aim to assess the impact different scenarios of agricultural production would have on biodiversity, considering the productivity of agricultural systems.

Methods

Literature review, expert interviews, meta-analysis and modeling.

Results (expected)

Classification of diversity and intensity of agricultural systems at global level. Characterization of the identified agricultural systems in terms of productivity and biodiversity. Modeling impacts of use on inputs on biodiversity on natural ecosystems. Evaluation of scenarios of agricultural production to produce enough food while preserving biodiversity.

Publications

López Rodríguez, S., van Bussel, L.G.J. and Alkemade, R. (2024) Classification of agricultural land management systems for global modeling of biodiversity and ecosystem services. Agric. Ecosyst. Environ. 360, 108795 https://doi.org/10.1016/j.agee.2023.108795

Other information

This project is in collaboration with PBL Netherlands Environmental Assessment Agency.

I want to create a collection of pictures of agricultural fields. If you have pictures you don't mind sharing, please contact me!

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Economic evaluation and financing of river restoration

Research challenges

The Green Deal and various EU directives promote restoration of a more natural functioning of Europe's river ecosystems: yet, progress to date remains limited. One of the barriers to scaling up restoration is the lack of integrated economic assessment tools and experience with their application. Funding and finance present another barrier to increase restoration: current investments in restoration are insufficient and too fragmented to achieve the required scale to meet EU goals, and a coherent articulation of how river restoration can be funded and financed at scale is lacking. Against this background, this PhD research aims at developing economic rationales for large-scale restoration of Europe's rivers and suggesting ways to finance this restoration.

Methods

The research combines hydrological modelling, ecosystem services valuation and cost-benefits analysis, to understand, quantify and compare the effects of different river restoration programs in the Netherlands and Portugal. Potential funding and financing strategies for the preferred restoration programs will be identified building on existing financing frameworks.

Results (expected)

By quantifying the development of a wide array of hydrological and non-hydrological ecosystem services, the research adds to the knowledge gap on integrated ecosystem services assessment in large-scale river restoration. The analysis will also contribute to increased understanding of trade-offs between ecosystem services at different spatial and temporal scales under restoration interventions. Results are expected to offer new insights in the economic rationale for investment in restoration, and the formulation of at-scale funding and financing strategies for river restoration in the EU. Finally, the research will contribute to overcoming funding and financing barriers by developing program-scale funding and financing strategies and reviewing their scalability in other (but similar) contexts across Europe.

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Modelling Ecosystem Services for Applying Nature-based Solutions for Environmental Challenges (PhD project)

Research challenges

Ecosystems are crucial for human well-being, offering resources like food and clean water. Enhancing them can help tackle climate change and biodiversity loss. This research provides insights on sustainable solutions.

Methods

Mapping, modelling of ecosystem services and Nature-based Solutions.

Results (expected)

This study addresses gaps by quantifying ecosystem services, adapting models for practitioners, estimating the contribution of nature-based solutions to policy goals, and identifying effective implementation locations. Overall, it aims to bolster the integration of nature-based solutions into policy and practice.

Publications

Knegt, B. de et al. (2022). Natural Capital Model. Wettelijke Onderzoekstaken Natuur & Milieu, WOt-technical report 236.

Knegt, B. de et al. (2020). Graadmeter Diensten van Natuur, update 2020; Vraag, aanbod, gebruik en trend van goederen en diensten uit ecosystemen in Nederland. Wettelijke Onderzoekstaken Natuur & Milieu, WOt-technical report 197. 136 blz.; 64 fig.; 16 tab.; 112 ref; 2 Bijlagen.

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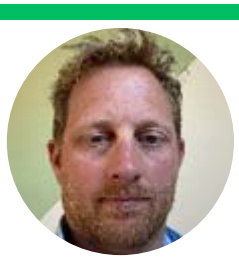

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Climate change and land use change in Sub-Saharan Africa: Investments in agriculture, livelihoods, and conservation

Research challenges

Climate change and land use change are two major driving forces of global change but are rarely considered jointly. Their synergistic impacts have large consequences on humans and the environment. Significant financial means are necessary to deal with these challenges. However, there is insufficient climate and biodiversity finance available to ensure a climate-resilient and biodiverse world. This research looks at the needs that arise from these impacts, assesses whether current climate and biodiversity funding is in line with those needs, proposes a framework for improved investment decision-making, and provides a case study. There is a focus on Sub-Saharan Africa, a region where land use change is common, climate change impacts are expected to high, and limited funding is available.

Methods

The method includes a combination of literature review, descriptive statistics, regression analysis and a case study.

Results (expected)

The results should contribute to an improved and integrated understanding of the interactions between climate and biodiversity, prioritization of climate and biodiversity funding, and aims to provide a practical contribution to climate adaptation and biodiversity policymakers and the investment community through suggestions for improved decision-making that yields better environmental and social outcomes.

Publications

Bosma, C. and L. Hein (2023). The climate and land use nexus: Implications for designing adaptation and conservation investment strategies in Sub-Saharan Africa. Sustainable Development, 1-20.

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Analysing the sustainability of starch biobased plastic production in Indonesia

Research challenges

Despite the extensive campaigns to reduce its use, the increasing demand for plastics highlights concerns about reliance on fossil fuels and the impact of plastic pollution. Starch-based bioplastics have become one of the primary alternatives to fossil-based plastics due to starch availability and technological readiness. In the Indonesian market, cassava starch is commonly used as a raw material for bioplastic manufacturing. However, using food sources like cassava for bioplastic production raises sustainability and food security issues. Therefore, it is crucial to explore other starch sources that have minimal impact on food supplies and the environment, such as sago, to assess how beneficial these alternatives are compared to cassava.

Methods

Our research will analyse the sustainability of current production and waste management of biobased plastic in Indonesia. In doing this, a life cycle and environmental cost-benefit analysis will be employed to assess cassava starch bioplastics' economic, social, and environmental impact and other starch alternatives such as sago. Subsequently, the study will analyse the feasibility of expanding starch production and explore scenarios to support a circular economy strategy in biobased-bioplastic waste management.

Results (expected)

- Comprehensive assessment of the current biobased plastic supply chains
- Spatial information on starch potential production for biobased plastics
- Future scenarios for sustainable biobased plastic supply chains
- Policy suggestion to support the enabling factors for sustainable biobased plastic production

My PhD is funded by the Indonesia Endowment Fund for Education Agency (LPDP)

lembaga pengelola dana pendidikan

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5.2

Research projects

Climate Services and Adaptation (CSA)

WAGRINNOVA – Co-innovations across scales to enhance sustainable intensification in water-managed agricultural systems in West Africa

Research challenges

The project proposes a multi-scale multi-actor and multi-discipline approach for the sustainable intensification of a new, dynamic, inclusive, market-oriented agriculture and technology-based agriculture. WAGRINNOVA aspires to change the development paradigm of water-managed agricultural systems and suggests that sustainable intensification is not achieved through stand-alone technology, but by combining technologies and governance to co-design productions systems that are best adapted to local conditions. WAGRINNOVA envisions sustainable intensification as the springboard that will transform irrigation and lowland communities into resilient, food-secure communities, improving their well-being through economic growth.

Methods

We have developed a tool i.e., DROP App to provide smallholder farmers with limited access to Information and Communications Technology (ICT) services with actionable information on rainfall and soil moisture for the short and medium term. The development process was carefully organized using a multitude of interactive methods, such as interviews and focus group discussions, capacity building of farmers on weather forecasting, capacity building of researcher on understanding farmer practices, and workshop and training at University of Development Studies in Tamale, Ghana.

Results (Expected)

Farmers were clear about the need for better rainfall and soil moisture information. Their current sources (radio and local knowledge) proved not to be sufficient. Farmers were motivated to collaborate in the design process, because they saw the value of better forecasts and of acquiring more knowledge on weather forecasting in general. Although the DROP app is always being improved, the fact that its design is based in a co-production process promises it to be usable and to offer actionable information.

Publications

- Gbangou et al. 2020. Rainfall and dry spell occurrence in Ghana: trends and seasonal predictions with a dynamical and a statistical model. Theor. and Appl. Climatol., 141, 371-387.
- Gbangou, et al. 2019. Seasonal variability and predictability of agrometeorological indices: Tailoring onset of rainy season estimation to meet farmers' needs in Ghana. Climate Services, 14, 19-30.
- Gbangou et al. 2020. Coproducing weather forecast information with and for smallholder farmers in Ghana: Evaluation and design principles. Atmosphere, 11, 902.
- Gbangou et al. 2020. Harnessing local forecasting knowledge on weather and climate in Ghana: documentation, skills and integration with scientific forecasting knowledge. Weather, Climate, and Society, 1-41.
- Paparrizos et al. 2023. Local rainfall forecast knowledge across the globe used for agricultural decision-making, Science of the Total Environment, 899, 165539.
- Paparrizos et al. 2023. Hydro-climate information services for smallholder farmers: FarmerSupport app principle, implementation, and evaluation, Climate Services, 30, 100387..

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Safeguarding African Foodsheds and Ecosystems for all Actorsacross Local, regional and international Levels to manage migration (SAFE4ALL)

Research Introduction

TAgriculture is the foundation of the livelihoods of billions of people worldwide, including African rural and urban households, farming communities, and cities. However, weather and climate risks have increased, creating a need for better access to climate and weather information, soil water management, insurance, and other climate-agricultural services. Although some services exist, they are often separated and follow a top-down information
provision that operates on a national scale.

Research Challenges

SAFE4ALL aims to address the interconnected issues of climate change, food security, ecosystem and disaster management, and migration in Africa by providing user-centered climate services. It will innovate and bundle affordable, and scalable services that include location-specific information to meet the needs of end-users in Kenya, Ghana and Zimbabwe. Three co-creation case studies will be organized in these African countries, engaging with small-scale farming communities, municipalities, and cities.

(Expected) Results

SAFE4ALL will coordinate efforts from governments, civil society, academia, and international organizations to mobilize the capacity of end-users, build food security and resilience, promote sustainable agriculture, and provide social safety nets to affected localities. Specific objectives include establishing a collaborative, co-creation, and engagement platform for the prioritization and co-development of needs-based climate services, identifying adaptation challenges, requirements, and enabling factors and complementing policies in adapting to the wider socio-economic environment, and exploring and harnessing existing services to improve the uptake and effectiveness of climate services and develop sustainable business and implementation models for services. The outcomes aim to manage migration to cities by ensuring that communities are better equipped to adapt and cope with the impacts of climate change while enhancing food security in a rapidly changing world.

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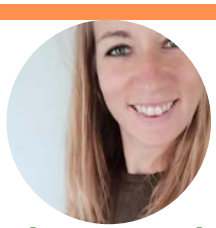

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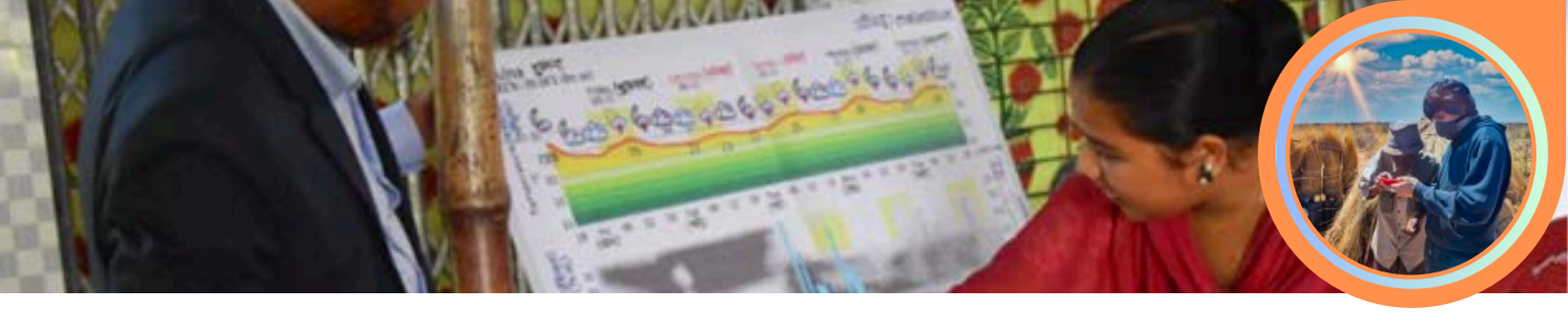

WATERAPPscale – upscaling WATERAPPs information services for sustainable food production in peri-urban delta areas in Bangladesh

Research challenges

Rural households and farming communities in the Bangladesh delta are increasingly developing their agricultural operations and are becoming more (urban) market oriented. Growing higher value crops is essential in further delta development. However, climate and weather risks of the crops are also growing. An important adaptation strategy to cope for example from events like the cyclone Amphan, is to become better informed about weather and climate variability and change.

Methods

WATERAPPscale project aims to upscale the WATERAPPS activities following the 'weather club' example, to other regional farming communities in Bangladesh by: 1) implementing the design principles for weather and climate information services for smallholder farmers that were co-produced at a local scale into 5 new locations, serving as basis for generic Bangladesh design principles, and 2) upscale the FarmerSupport app for use in Bangladesh to increase the resilience of local vulnerable farmers to a changing climate and unlock their farm potential. Many farmers' weather schools were established and we employed semi-structured interview and focus group discussion during the project.

Results (Expected)

The forecasts provided by the FSapp and shared in the weather schools greatly helped and provided actionable knowledge in many smallholder farmers in their daily agricultural decision-making toward more extreme weather resilience. One of the numerous success stories, Bijon Bairagi, a farmer from Sholmari weather school mentioned: "We received the forecast; my father and I stopped harvesting. I said to my father that we must bring the harvested rice from the field back home quickly. If we had continued harvesting, it would not be possible for us to take all the harvested rice home before heavy rainfall on Saturday and we would have suffered great losses". With the WATERAPPscale services, Bijon and many other farmers will be able to secure their families' food production and increase their economic output. .

Publications

- Sutanto et al. (under review). The performance of scientific, indigenous, and hybrid weather forecast.
- Sutanto et al. (under review). The DROP app: a soil moisture enabled CIS.

In a close collaboration with Khulna University

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ML-CLIMATE - improving climate information services for sustainable agriculture by integrating scientific and indigenous forecasts using Machine learning techniques

Research challenges

Smallholder farmers have limited prior knowledge and access to scientific weather forecasting (SF). They use different forecasting techniques that rely on their local or indigenous forecast (IF) knowledge, which is based on agrometeorological indicators they observe in the field. Many scientists emphasize the necessity of acknowledging IF and combining the IF and SF systems, here it is called hybrid forecasts (HF). The integration of IF and SF into HF yields more accurate and skillful forecasts compared to IF and SF alone. The objective of the ML-CLIMATE is studying the potential of machine learning (ML) techniques to improve climate services using HF derived from the IF knowledge and SF knowledge obtained from climate and weather prediction models.

Methods

The integration of IF with SF will be performed by testing different ML techniques, such as random forest, neural network, and log regression to deliver a skillful HF system. The ML algorithms will be trained using the indigenous forecast indicators and scientific forecasts as predictors and the observed data as response variables. The skill of the forecasts will be evaluated using statistical metrics.

Results (Expected)

We have developed the ML algorithm which is now being implemented in the DROP app, and an interactive StoryMap, where we visualize more than 1400 local ecological indicators in more than 65 regions around the world.

Publications

Sutanto et al. (in preparation). Hybrid forecasting using ML approaches.

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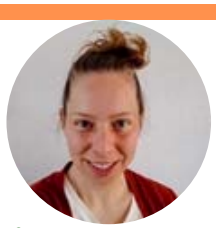

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Developing novel machine learning algorithms for predicting future compound drought and heatwave impacts in Europe (CDHEU)

Research challenges

The impacts of compound drought and heatwave events (CDH) will be higher in the future due to an increase in the probability of these events in the warming world we are experiencing. Most research on drought and heatwaves is mainly concentrated on the occurrences of past events, forecasting of these hazards, and projecting the future events of single hazards only and ignoring CDH events. More importantly, no impacts of these extreme events have been predicted. Information on the impacts of CDHs is crucial for climate adaptation, as these impacts are the ones that we want to prepare for.

Methods

Predicting future CDH events and their associated impacts e.g., in agriculture, ecosystems, energy and industry, and water borne transportation is possible but requires novel approaches. Machine learning (ML) approaches have been used in drought studies to predict historical drought hazard occurrences, develop drought impact functions, and forecast drought impacts. These techniques, therefore, offer a new opportunity for predicting future CDH impacts.

Results (Expected)

The expected results generated by this project are 1) Maps showing both future single and compound hazard hotspots, 2) a dashboard consisting of drought and heatwave impact databases for Europe, 3) ML algorithms for predicting future CDH impacts, and 4) a scientific publication on CDH impact in Europe.

Publications

Sutanto et al. (in preparation). Compound and cascading drought and heatwave impacts in Europe under global warming.

In a close collaboration with CR group in WENR

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Low-cost Disaster & Emergency Services for Communities At Risk (LODESTAR)

Research challenges

Despite several state and autonomous efforts for disaster management, and early warning systems (EWS) predicting pluvial and fluvial floods, communities and agencies struggle to cope with extreme precipitation and drought events. Even in drought mitigation, substantial gaps remain, concerning forecasting and early warning, considering the slow onset of the event. Today, efforts for better disaster preparedness and several EWSs are operational in India. These systems, however, lack sufficient lead times for disaster preparedness, accuracy, are dedicated to single hazards only, and do not integrate stakeholder (citizens and impacted communities) knowledge. There is therefore scope to develop a robust integrated EWS that provides multi hazard information far in advance..

Methods

LODESTAR intends to create a design for a MH-EWS by integrating cost-effective sensors for hydro-meteorological data assimilation, an ensemble of models (AI-ML, process-based climatic-hydrologic-hydraulic) to improve the system's lead time, reliability and accuracy, and consequently, enhance the resilience of communities at risk. Moreover, LODESTAR will employ a living labs approach for innovative, participatory, scientifically supported, socially acceptable solutions that lead to knowledge co-creation, and mitigating the social, economic and environmental impacts of disasters.

Results (Expected)

ThLODESTAR will be connected to several flagship programmes of the Government of India (GOI). For example, Digital India (use of digital technologies to improve management, enhance flood and drought forecasting, and improve EWS), Smart Cities (technology, data, and citizen engagement to create more livable and sustainable cities for the future), Swasth Bharat (promoting health and well-being), and STI policy (facilitate the diffusion and adoption of new technologies). LODESTAR also aligns with the flood protection programme (HWBP) under the aegis of the Dutch Delta Programme. Thus, effective disaster management, which LODESTAR proposes to do, will contribute to the progress of SDG 6, 11, and 13 targets.

In a close collaboration with SDC group and Indian partners

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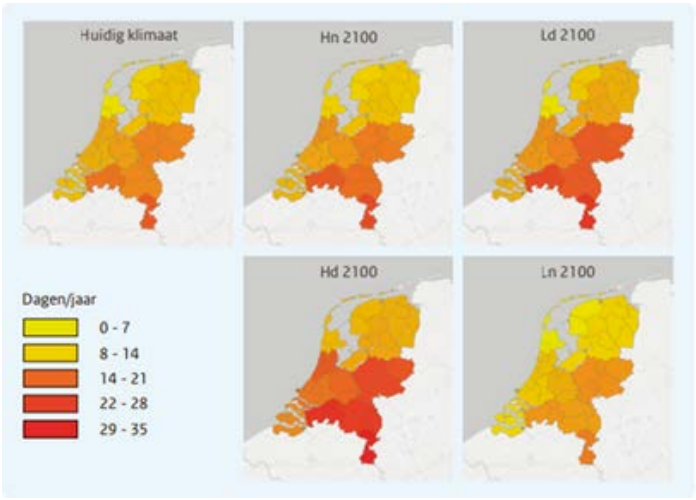
Towards wildfire risk reduction in North Western Europe

Research challenges

As wildfire suppression approaches its capacity limits, fuel accumulation peaks and fire danger increasing in the North Western Europe with climate change, addressing the increasing risk of wildfires becomes imperative within wildfire governance. To adopt a proactive stance, there is a pressing need for heightened risk awareness, enhanced collaboration, and effective knowledge exchange among stakeholders. This research aims to identify and address both barriers and enablers to achieving these objectives in wildfire governance.

Methods

The research methodology and approach involve employing a combination of methods, including literature review, expert interviews, climate change modeling, and online surveys. The study engages stakeholders who are wildfire professionals, such as forest managers, fire services personnel, and policy-makers primarily situated in North Western Europe.



Results (Expected)

(1) Analysis of the historical and future fire danger trends in the Netherlands under climate change,
(2) identification of the opportunities and challenges to adapt risk management to the emerging wildfire risk,
(3) assessment of the risk, weather and climate information land and forest managers need for informed land management decisions, and
(4) what lessons learnt can be learned from other hazards (flood and water management) to enhance wildfire risk governance.

This research received funding from the PyroLife project, funded by the European Union's Horizon 2020 research and innovation programme MSCA-ITN-2019 – Innovative Training Networks, under grant agreement No 860787.
https://pyrolife.lessonsonfire.eu

PyroLife CTFC MARIE CURIE ACTIONS

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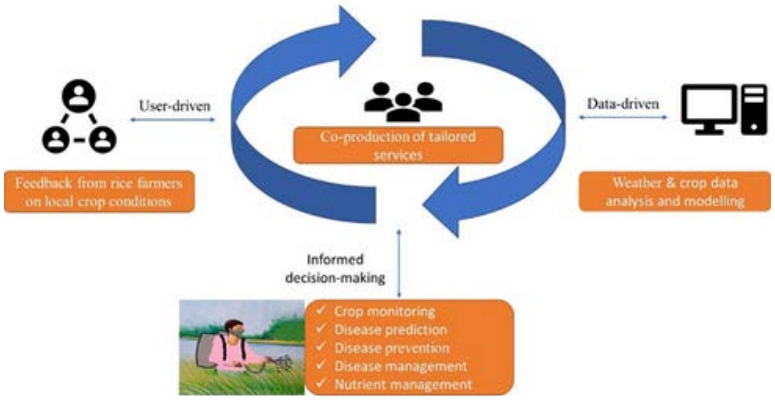
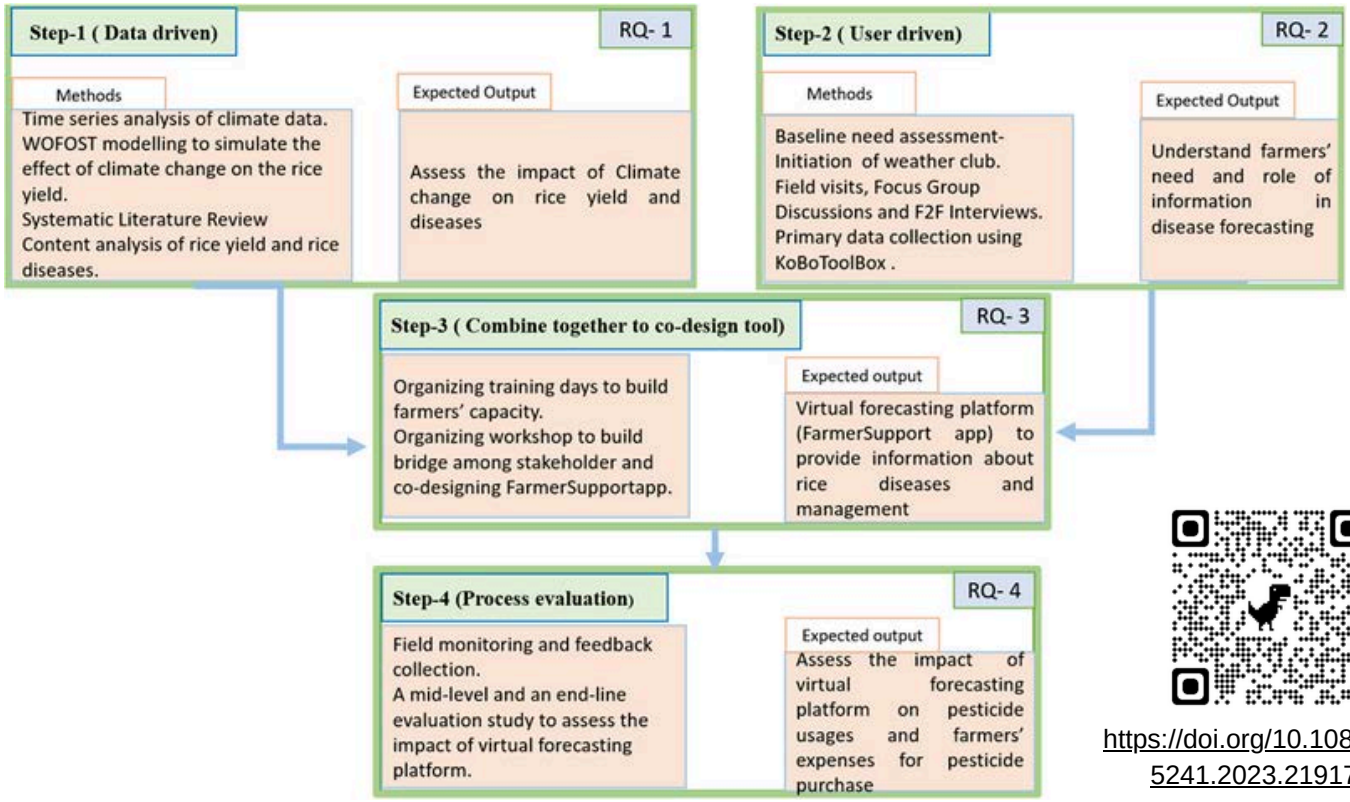
Farmer Friendly Climate Information Services for Climate Smart Rice Disease Management in Coastal Bangladesh

Research challenges

The major challenge for my research was developing a virtual platform-like app to forecast and manage rice diseases. Because it needs collaboration among experts from national and international meteorological and sectoral experts such as agriculturists, plant pathologists, weather experts, ICT experts, farmer representatives, and DAE personnel. Another challenge was balancing my PhD work and family life as I had a baby at the beginning of PhD.



Methods



https://doi.org/10.1080/27685241.2023.2191794

Results (Expected)

A need-based tailored climate information service will be developed to forecast rice diseases and manage them in advance in the context of climate smart agriculture.

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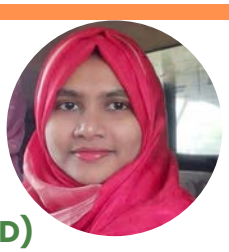

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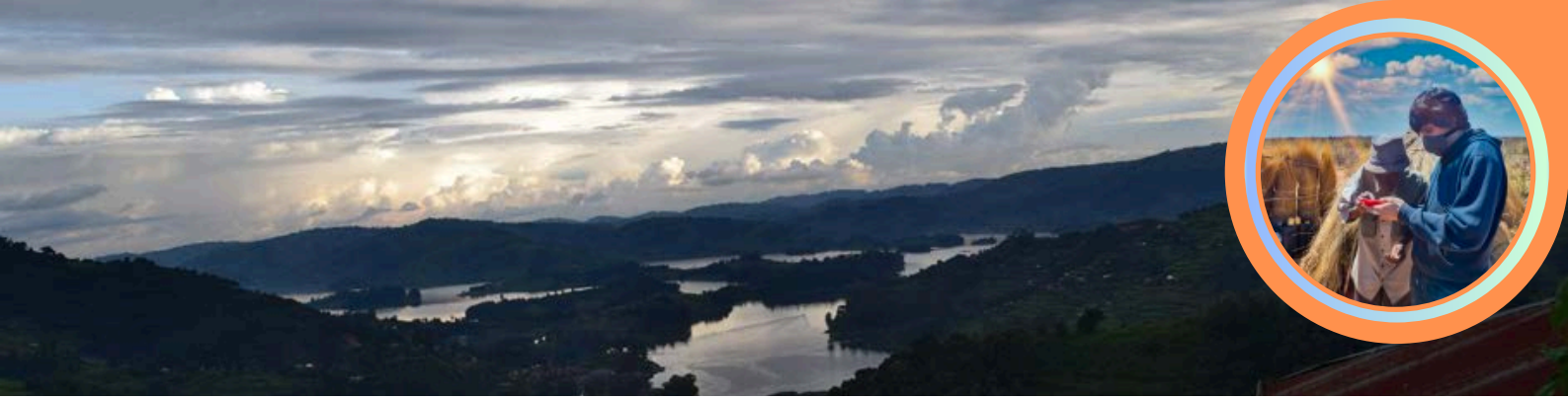

Scaling climate-smart agricultural interventions in agricultural production and ecosystem in East Africa: Assessing potential trade-offs, synergies, and limitations

Research challenges

Climate change and variability (CCV) are expected to have an incremental negative impact on agricultural systems and natural resources. Climate Smart agriculture(CSA) is a plausible approach to sustainable food systems under CCV because it combines conservation and production. Despite the potential benefits of CSA interventions, their scaling is low and slow for several reasons. Scaling of CSA interventions increases the resilience of agriculture value chains and ecosystems and, therefore, remains a priority. However, the challenge lies in understanding the complexities of agroecosystem processes to sustain agricultural production under contextual differences, resource scarcity and climate stresses. Information on the Spatio-temporal implication of CSA interventions at the macro-scale, to a large extent, is lacking and/or inadequate, costly, and time-consuming to collect, yet crucial in developing and prioritising investment portfolios for scaling CSA interventions.

Methods

Stocktaking of CSA scaling efforts combined with literature review.
Employing the WOFOST crop modelling process to assess the spatiotemporal impact of climate change on crop production.
Assess the efficacy of various adaptation measures to climate change.

Results (Expected)

The study highlights the experiences and critical lessons learned from scaling CSA. It guides decision-makers in formulating specific and inclusive scaling strategies that are sustainable in a developing country's context.
Spatio-temporal profile of potential impact of climate change on agricultural production and adaptation options.

Publications

Kirina, T.; Groot, A.; Shilomboleni, H.; Ludwig, F.; Demissie, T. Scaling Climate Smart Agriculture in East Africa: Experiences and Lessons. Agronomy 2022, 12, 820. https://doi.org/10.3390/agronomy12040820

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Assessing the potential of land restoration to deliver climate change adaptation in African drylands

Research challenges

Climate change and land degradation affects nature-based sectors with severe consequences on ecosystems and millions rural dwellers. Restoration could potentially address challenges of climate change and land degradation, together. However, there are still considerable knowledge gaps and uncertainties on what effective restoration is and whether restoration is helping African drylands communities adapt to climate change and tackle land degradation.

Methods

- Conduct narrative analysis on experts' understanding on effectiveness of ecosystem restoration in drylands.
- Use mental models to understand the underlying motivations for ecosystem restoration for different practitioners.
- Analyze trends in increasing vegetation cover against past climate trends to map out extreme events and the extent that increasing vegetation cover in providing adaptation outcomes.
- Develop climate resilient pathways with local communities.

Results (Expected)

To show whether land restoration is contributing to adaptation to extreme climate events in drylands and the extent that these results align with local community needs.

Publications

Onyango et al., 2024 (in prep). Restoring African Drylands: The narratives on effectiveness of restoration in Great Green Wall countries.

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Developing successful climate services: what works when and why?

Research challenges

Climate services are increasingly developed and applied to plan for adaptation to long-term climate change. Their success, however, is poorly defined and evaluated, potentially leading to wrong investments. This PhD research aims to contribute to this field, supporting better research, evaluation, and development of climate services for adaptation.

Methods

This research encompasses four studies:

1. Systematic map and literature review to describe what we already know
2. A global Delphi study to define climate service success with experts
3. An in-depth case study of a climate service co-production process to monitor success perceptions over time
4. Development of an evaluation framework and testing it in three cases

Results (Expected)

The first study found that there are diverging views on success criteria, resulting in different climate service approaches, outputs, and outcomes. The Delphi study resulted in a definition for successful climate services for adaptation consisting of 12 elements. Study three and four are ongoing.

"A climate service for adaptation is successful if producers work together with users[1], to develop a high-quality and usable service[2], while increasing users' capacities[3], and supporting them in adapting to climate change[4].

1. *Interaction between users and producers tailored to context; Establishment of trust between users and producers.*
2. *Accessible climate service; Relevant information; Credible information; Timely delivery; Communication format tailored to users; Uncertainty acknowledged and communicated.*
3. *Increases user understanding of an issue; Builds user capacity for using services.*
4. *Provides tangible or intangible benefits for the user; Contributes to better decision-making for adaptation."*

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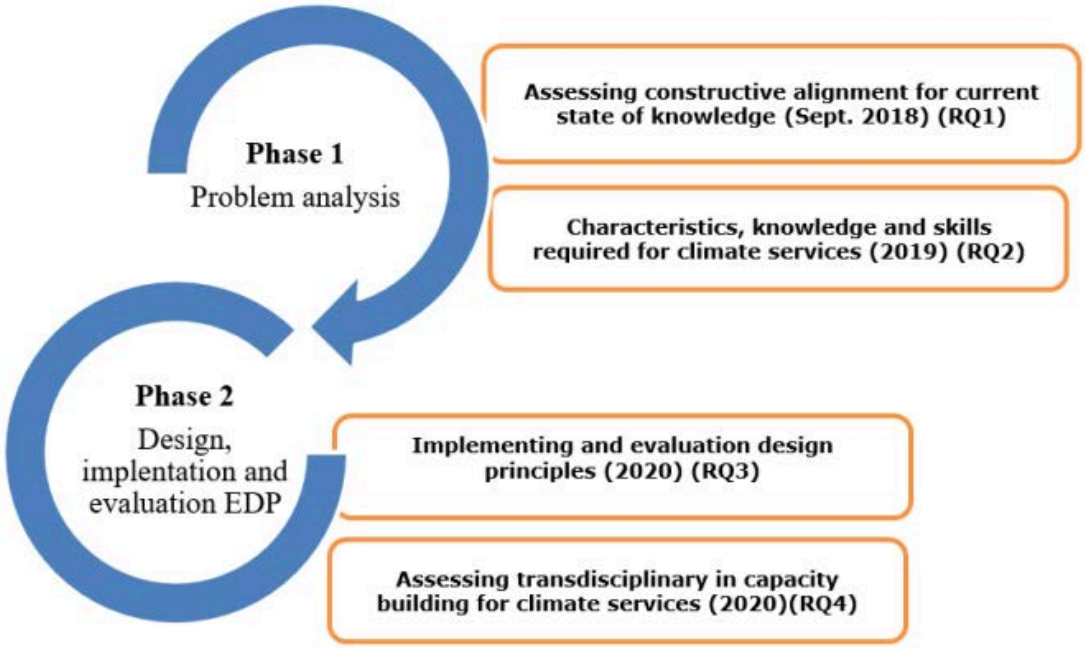
Educational principles in capacity building for climate services

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



More information

Results (Expected)

- 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.

Copernicus
Europe's eyes on Earth

Climate Change Service

C3S User Learning Services

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Enhancing C3S User Intelligence

Research challenges

- ECMWF, as the Entrusted Entity for the Copernicus Climate Change Service, invites tenders for the development and delivery of user intelligence and user uptake sessions.
- The successful Tenderer shall be responsible for the planning and implementation of targeted user engagement events to foster uptake of C3S products and services and collect user requirements.
- The Copernicus Climate Change Service (C3S) implemented by ECMWF on behalf of the European Union is a user-driven service with the aim to meet the needs of its users, now, and in the future.
- The ambition of C3S User Engagement is to increase user uptake and user satisfaction, promote the development of novel ways of using the data and provide training with the ultimate objective of enhancing the overall impact of the Copernicus services. In doing so, it supplements and closely collaborates with other user-oriented service components including scientific and technical expertise, C3S Service Desk, communication and outreach as well as evaluation and quality control.

Methods and expected results

- We lead Working Package 2 on collection and ingestion of User requirements, within this project.
- ECMWF intends to award a single multi-annual framework contract (maximum 36 months) for the planning and conduction of targeted user engagement activities and for the management and analysis of user requirements resulting from these activities as well as from other sources. The framework agreement shall be implemented via a single service contract (subject to negotiation) that is expected to commence in Q3 2023.

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5.3

Research projects

Empower Sustainable Futures (ESF)

Charting a new course: Proactively managing the growth of Antarctic tourism

Research challenges

This project seeks to simultaneously address two issues that Antarctic governance is currently grappling with – the challenges that the growth of Antarctic tourism poses to the environment; and the lack of resources for environmental research and monitoring – by tapping into the unique value that Antarctica represents for tourists. The project explores the viability of a system of tradable visitation permits for Antarctica: capping access to Antarctica and using the resulting scarcity to collect entrance fees.

Methods

1) to make a systematic assessment of the available options concerning the cap, initial allocation, allocation to end-users and trade; and
2) to simulate a range of possible systems of tradable visitation permits in order to test their performance in the Antarctic context;
3) optional: fieldwork in Antarctica.

Results (expected)

A simulated system of tradable visitation permits in Antarctica, and an overview of pros and cons associated with key design choices of such a system.

https://www.uu.nl/en/research/proactive-management-of-antarctic-tourism-proact

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Potentials and limitations of self-regulation in the Antarctic tourism industry from the perspective of environmental stewardship

Research challenges

In Antarctic tourism, environmental performance is primarily regulated by the industry itself due to the complex governance structure. This self-regulatory system has been functioning well, but is under increasing pressure from growing tourist and operator numbers and diversifying activities. This research examines the potentials and limitations of current and future self-regulation among Antarctic tourism operators from an environmental stewardship (ES) perspective:

1. How can ES help clarify the scope and meaning of self-regulation in the Antarctic tourism industry?
2. What are the potentials and limitations of self-regulation regarding the spatial distribution of tourism in the Antarctic?
3. What role does self-regulation play in tackling the mitigation of carbon emissions by the tourism industry in the Antarctic?

Methods

RQ	Data collection methods
RQ1	• Review of the literature on ES and self-regulation in Antarctic tourism • Review of self-regulatory instruments (guidelines and bylaws by the industry association IAATO) • Survey among tour operators
RQ2 & RQ3	• Mapping of tourism vessel itineraries • Carbon footprint calculations of Antarctic tourism • Elicitation interviews with tour operators, the industry association, NGO representatives and policy makers • Participant observation during a field trip to the Antarctic • Semi-structured interviews with tour guides and scientific staff

Results (expected)

Policy brief: implications concerning the future of (self-)regulation in the Antarctic tourism industry for policy and industry stakeholders

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Nature Today (daily news from nature)

Research challenges

Over forty nature organizations, knowledge institutes, governments and nature conservation organizations publish daily at least two nature reports on current developments in nature on Naturetoday.com. They aim to bring nature in the news domain and to increase the interest in and support for nature in society.

Methods

Experts from the partners publish nature reports, each according to a fixed frequency. The coordination of Naturetoday.com is done by the Foundation for Sustainable Development and the Earth Systems and Global Change Group of Wageningen University.
The content management system of Naturetoday.com contains a media module via which media can be actively informed. Furthermore, all nature reports are actively communicated via social media and people can subscribe to a daily or weekly email newsletter.

Results (expected)

Naturetoday.com has published over ten thousand nature reports. All reports together form a big archive with lots of nature information that is freely accessible via the website. The nature reports have been read millions of times. Many nature reports have generated a lot of media attention. Tens of thousands of people follow Nature Today via Twitter, Facebook, Linkedin and the Nature Today email newsletter.

Publications

https://www.naturetoday.com/intl/en/home (English)
https://www.naturetoday.com/intl/nl/home (Dutch)

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Nature’s Calendar: The Dutch phenological network

Research challenges

We monitor, analyse, forecast and communicate climate change induced changes in the timing of phenological events like the start of flowering, leaf colouring and the first appearance of birds and insects.

Methods

Nature’s Calendar is a citizen science project involving volunteers and school children that participate in the context of the GLOBE programme. The observers report their phenological observations via an online form (Natuurkalender.nl) or via the GrowApp (GrowApp.today).

Results (expected)

Based on the observations we conclude that due to climate change the length of the growing season in the period 2001 to 2020 was on average about one month longer than in the period 1940 to 1968.

We demonstrate that phenological changes have implications for many sectors in society including health and agriculture (see e.g. Muggenradar.nl and Tekenradar.nl)

The results of our research have resulted in hundreds of newspaper articles and radio and television interviews.

Publications

Natuurkalender.nl, GrowApp.today, Tekenradar.nl, Muggenradar.nl

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CONNECTS - Transdisciplinary learning for societal transformation

Research challenges

To address grand societal challenges, joint transdisciplinary efforts of scientists, engineers, governments, companies, and citizens are required. Fruitful collaboration is challenging because of differences in background, interests, and values, or conflicting perspectives. Higher education can play a key role in the development of transdisciplinary competencies, but transdisciplinary learning finds its way into curricula only with difficulty. Through an educational design research approach, this consortium including ten higher education institutions studies the question: What are principles for designing and implementing sustainable educational configurations that enable and scaffold transdisciplinary co-learning of students, teachers, and stakeholders, aiming to contribute to societal transformations?

Three major challenges:

- enabling co-learning among students, teachers, and stakeholders in a levelled learning space,
- scaffolding transdisciplinary learning, and
- embedding transdisciplinary education sustainably at curricular and organizational level.

Methods and Results (expected)

An educational design research approach is applied, aimed at formulating design principles, starting from state-of-the-art knowledge on transdisciplinary education. Multiple cycles of design, implementation, and evaluation of educational configurations in different contexts will result in nuanced, validated design principles and a deepened understanding of underlying mechanisms in different educational contexts, and established transdisciplinary educational practices. The framework with design principles will be translated into products to be utilized by teachers, teacher trainers and other groups of stakeholders.

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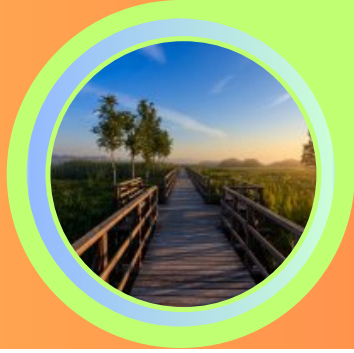
License to Skill: programmatic assessment of skills for Bachelor of Environmental Sciences (BES)



Research challenges

Skills are either not assessed at all or assessed as part of courses in most programmes at WUR. This assessment is often done through summative forms of assessment in exams, reports, and group projects. However, to measure students' development in skills, a more varied and robust way to assess students is needed.

In the last decade, programmatic assessment has gained traction as one of the ways to assess students' development. Core principles of programmatic assessment likely to be relevant are:

- Multiple assessments are used as 'data points' to gather information about learning process.
- Feedback on learning, is used by students to guide and steer their learning process.
- An assessment committee will evaluate the development of the skills.

Methods

This research will set up a pilot with 12 students over a period of around one year. Students will be supported in collecting these assessments and evaluations as data points to monitor and steer their learning in the skills.
At the end of the pilot year, the students will evaluate and be evaluated on their development together with an assessment committee to indicate the progress they made in their skills development and how to continue doing so.

Besides student learnings, important qualitative information on assessment of skills trajectories will be collected for the BES and other programmes at WUR.

Results (Expected)

The project will be successful if it generates concrete insights (formats, guidelines and procedures) in how (principles of) programmatic assessment of skills could be implemented in a BSc programme.

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DISTENDER – DevelopIng STratEgies by integrating mitigatioN, aDaptation and participation to climate changE Risks

Research challenges

- Stakeholder engagement process & participation using co-creation
- Participatory development of localized socio-economic scenarios
- Produce localized climate storylines through a downscaling framework
- Risk and vulnerability assessment based on a set of bio-physical, social and economic indicators produced by a wide range of multi-scale and cross-sectorial models
- Robust adaptation and mitigation actions and policies from a suite of harmonized strategies constructed through participatory methods
- Sectoral, integrated and economy-wide economic evaluation of climate strategies
- Translate scientific results into policy relevant actions
- Testing and replication of the outcomes of the project through case studies
- Network to promote and exchange the outputs of the projects with other EU and international initiatives about CC

Methods

DISTENDER is an EU-funded project developing actionable strategies for climate change mitigation and adaptation. The strategies will result from the integration of climate change adaptation and mitigation actions with participatory approaches bringing scientists, businesses, governments, policy makers and citizens together.

Five Case Studies at the EU level will be involved for testing the holistic approach developed by the project against specific climate risks and 6 additional Follower Case Studies are first in line for replication. Finally, a Decision Support System will be developed to help policy makers to take the most out of the knowledge, tools and recommendations generated by DISTENDER and further replicate them.

As WUR, we are involved in the development and implementation of participatory methods, including the co-creation of visions and pathways to climate resilient futures as well as socio-economic scenarios. Furthermore, from stakeholder-derived scenario narratives we develop quantitative outputs such as land use maps.

Results (expected)

DISTENDER will outline a methodology to identify the trade-offs and interactions between adaptation and mitigation measures under dynamical socioeconomic and climate scenarios. The DISTENDER methodology will be based on results from multiscale and multi-sector modelling tools.

https://distender.eu/
https://cordis.europa.eu/project/id/101056836

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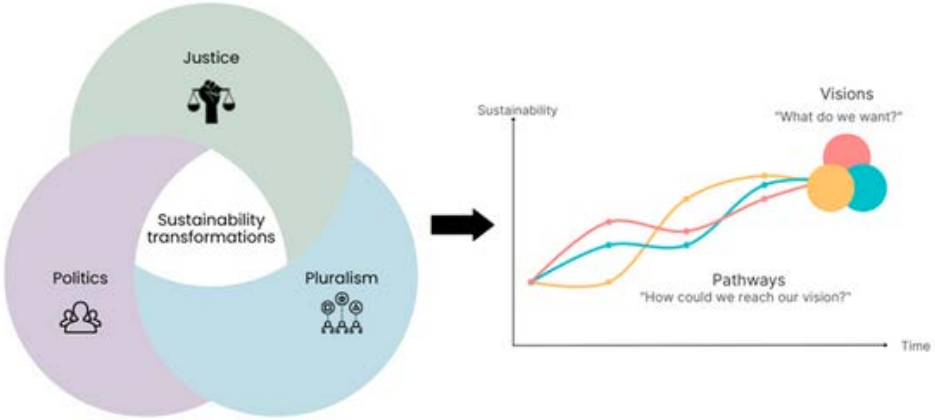
Navigating transformations: pluralism, politics, and justice in visions and pathways to sustainable futures

Research challenges

To address multiple global sustainability crises across social-ecological systems, researchers and institutions are increasingly calling for transformations to sustainable futures. However, there are key issues that remain unaddressed in current transformations research and practice. These include the underemphasis of the plural and political nature of sustainability transformations, and the limited engagement of justice in transformations. The aim of this PhD project is to center pluralism, politics, and justice in sustainability transformations by incorporating these theoretical concepts into participatory futures methods.

Theoretical framework

As part of the PhD project, I will develop a theoretical framework based on a literature review, drawing on critical social science theories to elaborate on the concepts of pluralism, politics, and justice, and applying these to participatory futures methods.



Methods & Results

Research question	Methods	Results
What is the role of human-nature relations in sustainable futures of the Wadden?	• Walking interviews • Semi-structured interviews • Photo-elicitation	• Identification of diverse human-nature relations and values of nature in the Wadden. • Sustainable human-nature relations need to be based on the co-existence of plural values, including relational, intrinsic, and instrumental values of nature.
How to include intergenerational and interspecies justice in visions of sustainable futures?	• Stakeholder workshop: visioning • Guiding workshop framework: Theory U	• (Expected) Implementing and evaluating technique to invite in silent voices (nature and future generations) into participatory visioning processes.
What are transformative pathways to sustainable futures?	• Stakeholder workshop: pathway development • Guiding workshop framework: X-curve	• (Expected) Transformative pathways consisting of actions to breakdown systemic and structural barriers to transformation and actions to experiment and accelerate towards visions of sustainable futures.

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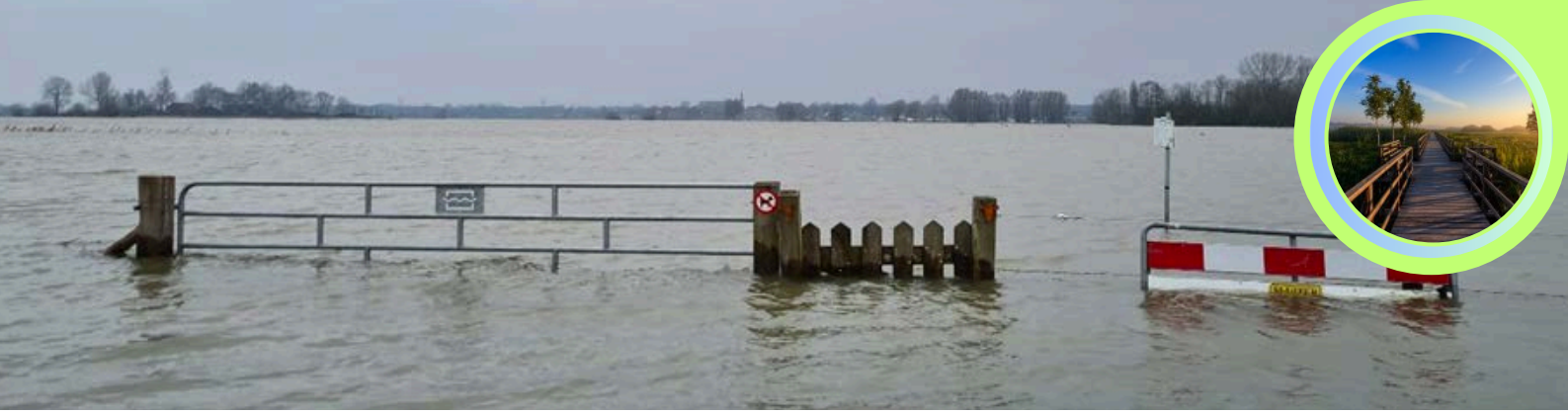

Conditions and participatory processes for effective design and dynamic management of multiscale Nature-based Solutions in the Netherlands

Research challenges

NbS can be vital elements in the transition towards climate-resilient landscapes. Many single scale NbS projects show clear benefits in improving resilience, but a system-oriented approach is often missing. This prevents effective use of NbS in regional development or land-use plans for climate-resilient landscapes. Conditions for the participatory design of multiscale NbS need to be developed. Linking this to knowledge of long term functioning and management of NbS under dynamic conditions should result in a governance framework for the design of climate resilient and Nature-based landscapes.

Methods

This research uses three methodological approaches: Descriptive research based on a realist approach with literature study and interviews; action-oriented research involving living labs and participatory approaches for a design-oriented approach of multiscale NbS.

Results (Expected)

The overall goal of this research is to improve application of NbS for climate resilient landscapes through more effective design of multiscale NbS by providing practical design conditions. Use and management of NbS will benefit from the participatory governance framework.

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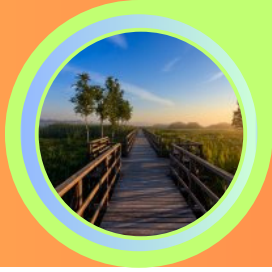
CASTOR (CAtchment Strategies TOwards Resilience)



Research challenges

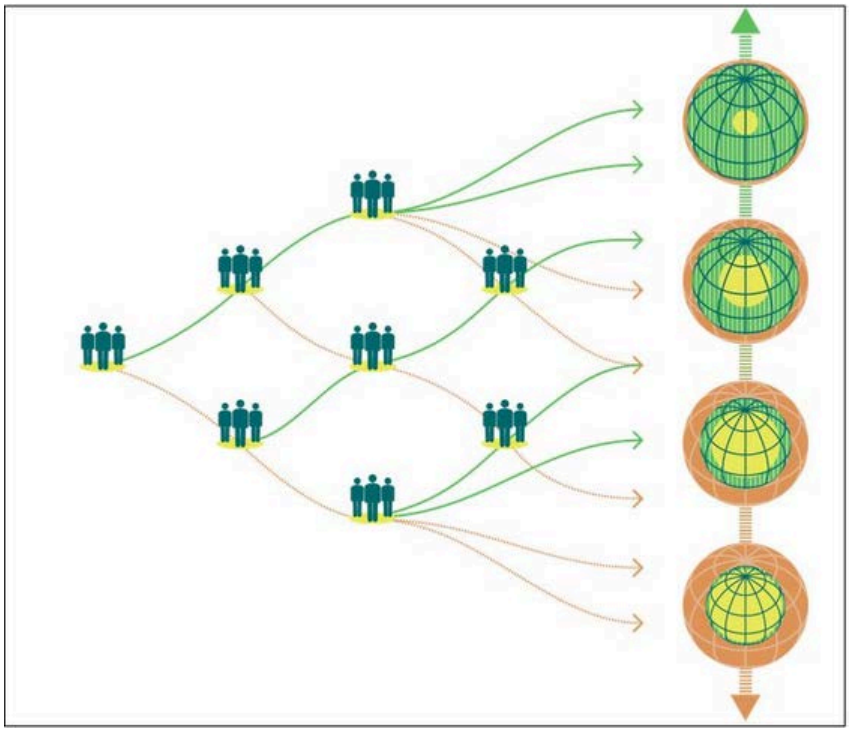
Adaptation pathways are starting to become more commonplace in policy processes, however several challenges persist in de application of the concept:

- How to organize stakeholder interaction for different purposes
- What are benefits compared to 'traditional' planning practices (in the Netherlands)
- How to connect short and long term policy objectives on different scales
- How can adaptation pathways be appraised

These challenges are researched in the context of the sandy soil landscapes in the Netherlands.

Methods

A mix of literature review and stakeholder interaction. Interaction is organized around the sandy soils landscapes in the Netherland with a variety of stakeholders ranging from farmers, concerned citizens and NGO to different governmental stakeholders.



Results (Expected)

The expected outcomes include:

- An overview of, and recommendation for, organizing co-creation and collaborative learning in the development of adaptation pathways.
- Pathways for the drinking water sector, with a reflection on the merits of using pathways compared to 'traditional' planning methods.
- Bridging scales and their adaptation objectives using pathways.
- An appraisal framework to assess existing pathways in the Netherlands.

Publications

Smolenaars, W. J., Sommerauer, W. J. W., van der Bolt, B., Jamil, M. K., Dhaubanjar, S., Lutz, A., ... & Biemans, H. (2023). Spatial adaptation pathways to reconcile future water and food security in the Indus River basin. Communications Earth & Environment, 4(1), 410.

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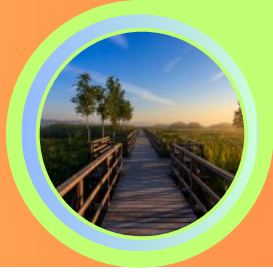
Transdisciplinary Research: Adaptive Wildland Fire Risk Management in Mediterranean Social-Ecological Systems



Research challenges

Rural Mediterranean communities and ecosystems face many overlapping challenges. Pressures like depopulation and climate change exacerbate already vulnerable and rapidly changing landscapes. Fire, once a land management tool, has now become a threat due to larger, more frequent and uncontrollable events. This research project develops a transdisciplinary framework that encourages a suite of adaptive land management tools to support wildland fire risk reduction efforts in rural and semi-rural Mediterranean communities.

Methods & (expected) results

Our transdisciplinary project focuses on co-creating adaptation pathways for wildland fire risk reduction. For this, we first aimed to better understand the local social contexts of rural Mediterranean areas and how these factors influence adaptive capacity to wildland fire through qualitative methods. Then, we conducted a series of participatory workshops in the Montseny watershed of Catalonia with the purpose of elevating local knowledge and encouraging social learning in adaptation pathways processes. Finally, a literature review of transdisciplinary fire research to date outlines the challenges and opportunities for this field's growth. Through this collaborative research, I have worked directly with fire managers, actors in local governance, sustainable farmers and foresters, and other grassroots initiatives.

We argue the need for deepened empirical transdisciplinary research to connect fire and land management tailored to local characteristics. Centering these local perspectives and diverse cultural values is necessary to foster long term adaptive wildland fire management strategies in rural Mediterranean communities and globally.

Publications

Uyttewaal, K., Prat-Guitart, N., Ludwig, F., Kroeze, F., Langer, E.R. (Lisa). (2023). Territories in Transition: how social contexts influence wildland fire adaptive capacity in rural Northwestern European Mediterranean areas. Fire Ecology. 19, 13.

This project has received funding from the European Union's Horizon 2020 research and innovation programme MSCA-ITN-2019 – Innovative Training Networks under grant agreement No 860787

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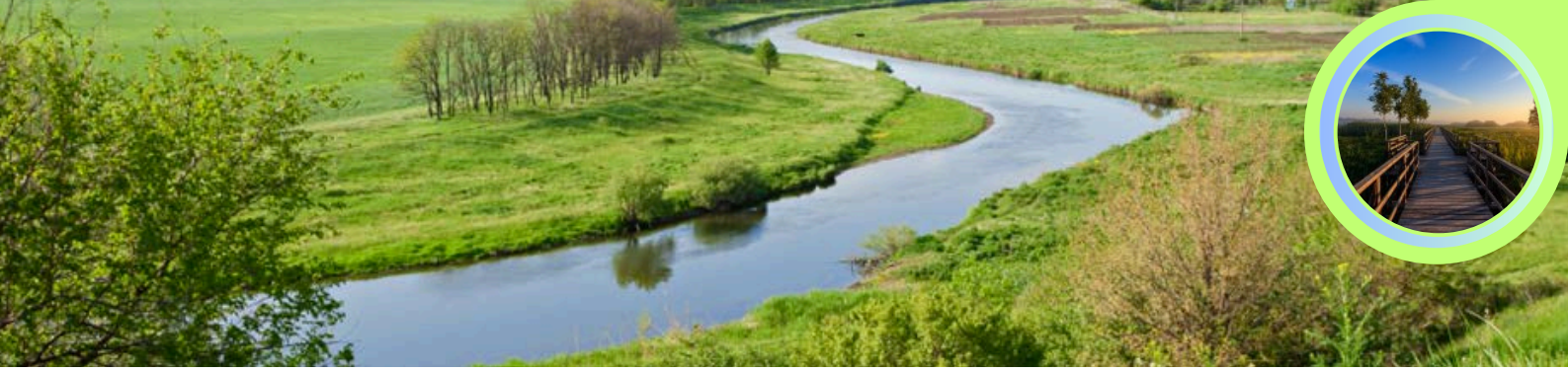

CASTOR: Bridging the gap between theory and practice for Adaptation Pathways

Research challenges

The sandy soil landscapes of the Netherlands are facing growing challenges. Land and water systems here sustain vital values for living, nature and recreation, but also provide resources for economic activities, such as industries, transport and agriculture. Simultaneously, there is an increasing need to adapt these diverse uses to the changing climate. The objective of the CASTOR project is to enable the transformation to, or safeguarding of, the outstanding quality of sandy soil landscapes, building on existing features. Given the aforementioned challenges, this requires a long-term (complex adaptive) systems perspective and an understanding of the connectedness and interdependence of natural processes and human interventions at the landscape level.

Methods

1.Literature review to characterize the role, value and limitations of modelling for Adaptation Pathways processes

2.Experimental Pathways development workshops with stakeholders to test Pathways methodologies in practice

3. Ongoing reflection on guidelines and criteria for the climate-resilient development pathways creation

Results (Expected)

1.Overview of futures and multiple pathways for Dutch sandy soil landscapes

2.Understanding of advantages and downsides of model use in Pathways.

3. Guidelines for using climate-resilient development pathways in diverse contexts

Publications

Smolenaars, W. J., Sommerauer, W. J. W., van der Bolt, B., Jamil, M. K., Dhaubanjar, S., Lutz, A., ... & Biemans, H. (2023). Spatial adaptation pathways to reconcile future water and food security in the Indus River basin. Communications Earth & Environment, 4(1), 410.

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Pathways for climate resilient development in semi-arid regions of India

Research challenges

Semi-arid regions in India are characterised by agriculture-based livelihoods, which are increasingly exposed to extreme weather events. The uncertainties in future climate and socio-economic changes pose further challenges in effectively building resilience within semi-arid farming systems. The overall objective of the research is to advance the climate resilient development of semi-arid farming systems in India

Methods

This overall objective is subdivided into the following specific objectives: (1) develop a context-specific framework to assess the climate resilience of semi-arid farming systems in India, (2) retrospectively assess the contribution of agricultural development interventions to the climate resilience of farming systems in semi-arid India, (3) identify and characterise critical climate-stress moments for semi-arid farming systems in India, and (4) create climate resilient development pathways for farmer producer organisations in semi-arid farming systems in India. The overarching research framework adopted in the project integrates the concepts of climate resilience, development, climate action, and pathways towards advancing climate resilient development. A mixed methods approach is applied, incorporating both quantitative and qualitative data.

Results (Expected)

The complexity of issues faced by semi-arid farming systems in India requires a holistic (integrating climate and development concerns) yet context-specific understanding of climate resilience. The research also shows that evolving aspirations, climate change risks, and contested visions for the future require a dynamic response for advancing climate resilient development that can be met by adopting a climate-resilient development pathway approach.

Publications

- Srinidhi, A., Werners, S. E., Ludwig, F., D'Souza, M., & Meuwissen, M. P. M. (2023). Assessing the Climate Resilience of Semi-Arid Farming Systems in India: Framework and Application. In A. K. Mishra, S. C. Kumbhakar, & G. Lien (Eds.), Managing Risk in Agriculture: A Development Perspective (pp. 208-224). CAB International. https://doi.org/10.1079/9781800622289.0015
- Srinidhi, A., Werners, S. E., Dadas, D., D'Souza, M., Ludwig, F., & Meuwissen, M. P. M. (2023). Retrospective climate resilience assessment of semi-arid farming systems in India. International Journal of Water Resources Development. https://doi.org/10.1080/07900627.2023.2207680

The research is being conducted in collaboration with the Watershed Organisation Trust, an NGO based in Pune, India. http://www.wotr.org/

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Exploring the role of learning in transformations towards sustainable and just landscapes

Research challenges

Catalysing transformative change towards more sustainable and just landscapes demands a systemic approach, to more effectively navigate complex, cross-scale, social-ecological dynamics, and target problems at their root. To facilitate this, learning, especially transformative learning among diverse stakeholders, has been considered a fundamental mechanism. However, in-depth empirical research to rigorously study the role of learning in transformations towards sustainable and just landscapes is lacking, leaving a largely normative and abstract understanding of the nature of this learning and how it can be facilitated. This research aims to address this gap, by asking how can learning contribute to transformative pathways towards more sustainable and just landscapes?

Methods & expected results

To answer this question, this research will firstly explore learning over time, in the context of landscape governance approaches aiming to address multiple interconnected social-ecological challenges. Secondly, the research will investigate learning through more targeted knowledge co-production interventions in a particular Dutch case study, focusing on understanding landscapes as complex social-ecological systems, and co-designing transformative pathways towards a sustainable and just landscape future.

Finally, the research will conduct an in-depth exploration into the role that learning played in shaping the co-designed pathways. These objectives will be achieved through a mixed-methods approach, including academic and grey literature reviews, semi-structured interviews, and participatory co-design workshops combining group model building and futures methods.

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Climate change mitigation and policy adoption

Research challenges

Climate change results in unprecedented and rapid changes in the Earth's systems . These changes are expected to reach devastating levels if countries do not reduce their greenhouse gas emissions, hereafter emissions, to zero and collectively limit the end-of century temperature increase to 1.5 °C. The Paris Agreement requires that countries submit and update their Nationally Determined Contributions (NDCs) to mitigate global climate change.

Methods & results

To identify means to improve mitigation efforts, we investigated whether the number of climate policies is associated with emission projections up to 2030 and compared policies' prevalence across country groups. We use a comprehensive policy dataset to calculate the number of climate policies in force, or policy density. We used linear regressions to investigate whether the total number of climate policies, or policy density, explains the variance in projected emission-change rate distributions.

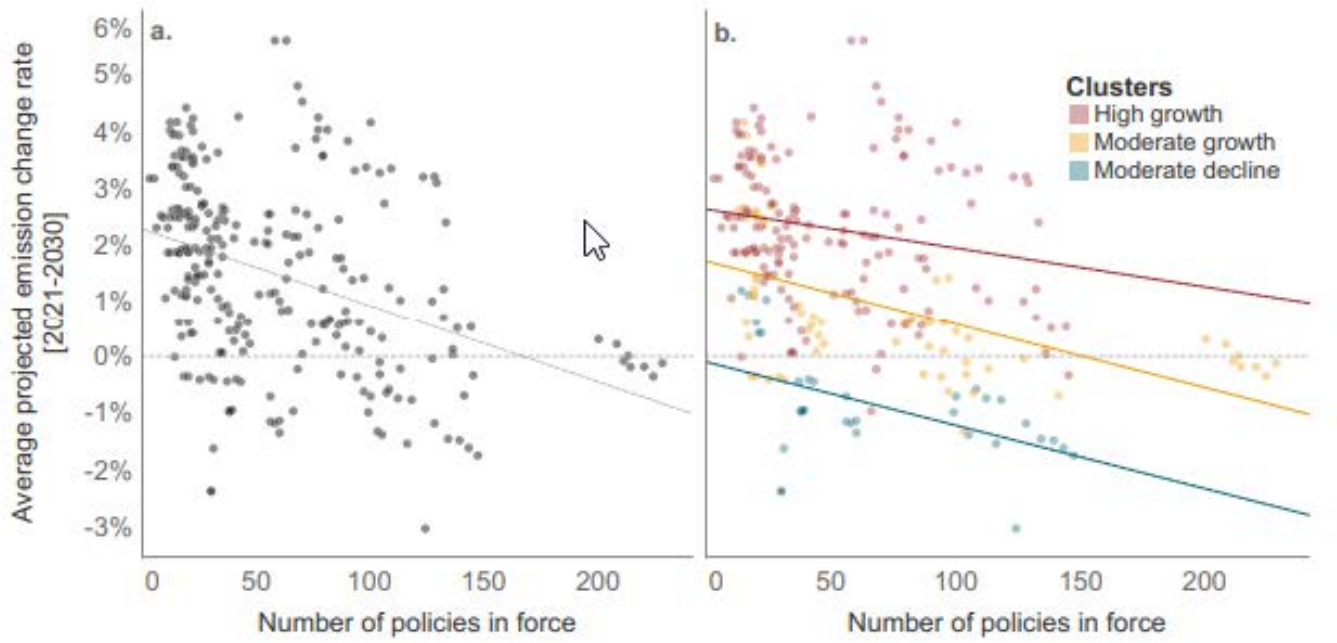

Figure shows the relationship between average annual projected emission change rates and a number of policies. Countries with more climate policies have lower projected emission change rates (a). This result is valid across clusters although to a different degree (b). Results are statistically significant despite variance (see https://doi.org/10.1038/s44168-023-00043-8). Additional information can be found in another paper (https://doi.org/10.1080/13876988.2023.2255151).

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5.4

Research projects

Land Based Mitigation and Adaptation (LBM)

Monitoring the Greenhouse gas exchange of peat soils: Netherlands Research Programme On Greenhouse Gas Dynamics In Peatlands And Organic Soils (NOBV) and Veenweideprogramma prov. Fryslân

Research challenges

The Dutch peatlands are dominated by peatlands at or below sea level, under use for dairy farming: the typical Ducth landscape of green pastures, ditches, cows and wind mills. And natural areas. The agricultural peat soils are being drained, are subsiding and emit CO2. In order to mitigate these greenhouse gas emissions, several management measures are being proposed, and a national consortium of institutes and universities (NOBV and Fryslân province) is investigating their effectiveness, the underlying processes and is designing a long-term monitoring system.

Methods

ESC contributes to this with eddy covariance flux measurements in almost 20 locations, and with airborne measurements (see Ruysdael page) quantifying gas exchange of CO2, CH4, water vapour and heat, representative of areas of one to several hectares (or square kilometers for the airborne data). In addition, environmental, soil and vegetation data are collected, and we are building a large database and data processing facility.

Results (expected)

CO2 emissions are expected to decrease with higher water tables, and nature areas are expected to absorb CO2 and methane gas to be emitted by inundated and more so in more nutrient-rich soils, but all this needs to be quantified. The end product of these projects will be better understanding of the underlying processes, quantification of emission factors, and a data-model based monitoring system in collaboration with the consortium partners.

Involved in the project

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Our partners in these projects are: Deltares, WENR, VU Amsterdam, RU Nijmegen, Utrecht University, Wetterskip Fryslân, Vereniging Natuurmonumenten.

www.nobveenweiden.nl

ERA-NET ReLive - Back to the Future: Re-integrating Land and Livestock for Greenhouse Gas Mitigation and Circularity

Research challenges

Enhancing circularity is an important aspect of making European agriculture greener and more sustainable. The widespread reintroduction of crops and livestock could make a major contribution to this through the more effective recycling of resources and the minimization of waste. However, this comes with significant challenges, including the potential for enhanced greenhouse gas (GHG) emissions (particularly methane emissions) from enteric fermentation, as well as from the need to effectively substitute all/most inorganic fertilizers with organic manures.
The ERA-NET Relive project, a collaboration of 11 universities and institutes ranging from Ireland to New Zealand and Finland to Chile, including the Netherlands, will take a holistic approach to the sustainable reintegration of livestock and cropping systems.

Methods

Modelling tools will be developed by partners, and a core activity led by the Earth Systems and Global Change Group of Wageningen University is to bring together, improve and test methods to directly verify the associated GHG emissions and co-design ways to mitigate these.

Results (expected)

Deliverables (expected) from work package led by Earth Systems and Global Change Group
·Advisory report on the optimal validation tools at farm level in a European context
·Dutch farm scale data for model evaluation
Digital platform with existing tools for managing and evaluating farm GHG management and Report on methodologies for evaluating small-scale alternative farming schemes

https://relive-era.net

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Peat Pals for LIFE

Research challenges

Peatlands are one of the most carbon-rich ecosystems on the planet with huge mitigation potential. They provide net cooling effect on climate, support biodiversity and provide important ecosystem services in their natural state. More than half of the European peatlands are drained and degraded due to various anthropogenic activities so it is crucial to conserve the natural and restore the degraded peatlands.

Peat pals for LIFE project will restore a variety of degraded and carbon rich peat ecosystems in the Netherlands and in Flanders which are influenced by climate change and anthropogenic activities. The overall objective is to improve the conservation status of these ecosystems and attain a favorable status of the Annex I habitats and associated species in N2000 areas. By doing this we will create a variety of peat ecosystems, which will be more resilient to external effects.

Methods

Various measures will be put in place to improve the hydrological condition of 260 ha raised bog in the Netherlands, and 56 ha peatland habitat in Flanders, Belgium. This will lead to quality improvement and extension of these habitats, but also will have a positive effect on the GHG budget of these carbon rich areas.

The Earth Systems and Global Change Group of Wageningen University will model the impacts of restoration on the carbon and GHG emissions. The output will be validated using Eddy Covariance measurements. Additionally, Socio-economic Impacts of restoration will be analyzed for all the sites.

Results (expected)

Deliverables (expected) from the Earth Systems and Global Change Group

- Before and after impact of restoration on the carbon and GHG emissions
- Interannual variability and the key drivers of emissions with hotspots
- Upscaling of the emissions at site scale

https://webgate.ec.europa.eu/life/publicWebsite/project/LIFE22-NAT-NL-Peat-Pals-101113679/peat-pals-for-life

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Data-driven modelling of Greenhouse gas balances of Dutch peatlands

Research challenges

In the context of the climate emergency, peat degradation in the Netherlands results in substantial greenhouse gas emissions for the Dutch agricultural sector. This situation has raised a trade-off between emissions, economic activity, cultural heritage and biodiversity; decision-makers want fast and unambiguous answers to start designing adaptation pathways. Since 2019, these emissions have been monitored by the Dutch National Research Programme on Greenhouse Gases in Peatlands (NOBV). These datasets support the development of models giving a holistic preview of the current emissions regarding climate drivers, soil types, land use, and groundwater management, including mitigation strategies.

Methods

By combining Eddy-Covariance Measurements (Ground and Airborne Measurements) with different data sources based on hydrological models and satellite data, the objective is to develop actionable and robust models modelling GHG Fluxes related to peat degradation. However, these aren't directly available from measurements; the measurements include fluxes produced from multiple biogeochemical processes and resulting from different landscape elements depending on the meteorological conditions. Hence, interpreting and partitioning the fluxes meaningfully via data-driven models is a non-trivial milestone in developing models aiming to operate at a larger scale.

Results (expected)

We ambition to quantify and better understand the emission mechanisms involving the mitigation strategies through data-driven modeling. Based on this, we aim to make an impact by generalizing the statement made at the site level at a larger scale and providing actionable tools to assist decision-makers and stakeholders. Building dynamic maps of the peat-degradation-related fluxes and annual GHG budgets are part of these tools.

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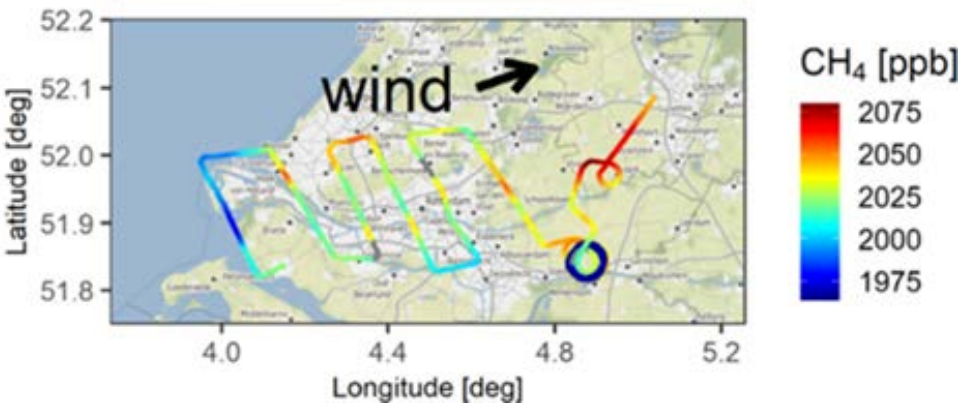

Ruysdael

Research challenges

The Ruisdael project (https://ruisdael-observatory.nl/)

Methods

With our research aircraft we observe horizontal and vertical gradients of trace gases (CO2 and CH4) with high absolute precision (sub ppm and ppb respectively) and particulate matter over rural and urban/industrial areas. From these gradients we infer regional emissions of both trace gases and aerosols.

We collaborate with RUG-CIO on methodological development of their AirCore instrument, which allows observing similar gradients for other trace gases such as N2O.

Results (expected)

These observation contribute to the verification of known and unknown sources, point sources and diffuse sources, such as land fills, refineries, LNG terminals etc.The observations also serve to validate and improve high resolution transport models (together with WUR-MAQ and TuD).

Publications

Xin Tong, Steven van Heuven, Bert Scheeren, Bert Kers, Ronald Hutjes, and Huilin Chen. Environmental Science & Technology 2023 57 (41), 15571-15579, DOI: 10.1021/acs.est.3c04932

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Copernicus Indicators for Global Agriculture

Research challenges

Develop well documented and well maintained operational climate datasets for the agricultural research community

Methods

After extensive consultation with the potential agricultural user community from industry, research and policy a number of critical research-based but consolidated datasets were identified to be published for open access.

Results (expected)

Data enable potential users to more easily than ever before to make assessments of present and future climate on agricultural production. This portal design and an API will also stimulate their uptake for the development of further downstream data products and climate services.

Publications

- Chevuru, de Wit, Supit, Hutjes (2023)
- Copernicus global crop productivity indicators: An evaluation based on regionally reported yields, Climate Services 30, 100374, doi: 10.1016/j.cliser.2023.100374.
- Boogaard, Schubert, de Wit, Lazebnik, Hutjes, Van der Grijn, (2020): Agrometeorological indicators from 1979 to present derived from reanalysis. Copernicus Climate Change Service (C3S) Climate Data Store (CDS). DOI: 10.24381/cds.6c68c9bb
- Nobakht, Beavis, O'Hara, Hutjes, Supit (2019): Agroclimatic indicators from 1951 to 2099 derived from climate projections. Copernicus Climate Change Service (C3S) Climate Data Store (CDS). DOI: 10.24381/cds.dad6e055
- de Wit, Elhaddad, Meyer, Turdukulov, Hutjes, (2022): Crop productivity and evapotranspiration indicators from 2000 to present derived from satellite observations. Copernicus Climate Change Service (C3S) Climate Data Store (CDS). DOI: 10.24381/cds.b2f6f9f6

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The climate effects of land restoration in Africa

Research challenges

To combat widespread land degradation, several land restoration initiatives have emerged across Africa, aiming to decrease or even reverse problems like erosion or biodiversity losses. The resulting increase in vegetation cover can affect land-atmosphere interactions and therefore the local climate. The aim of this PhD project is to determine biophysical climate effects of land restoration in Africa, in order to develop design guidelines for maximum positive climate effects of land restoration projects.

Methods

The research will be carried out using both satellite observations and atmospheric modelling. Satellite data is used to compare observed changes in vegetation cover with climate variables such as temperature, albedo and cloud cover on a continental scale. This is extended with several modelling case studies to obtain more insight into the underlying physical processes as well as variables that are more difficult to observe with satellite imagery.

Results (expected)

We hope to increase our knowledge on land-atmosphere interactions across Africa, with a focus on land restoration projects. Through this, we can provide guidelines for designing land restoration projects in order to optimize positive local climate effects.

Publications

Ruijsch, J., Teuling, A. J., Verbesselt, J., & Hutjes, R. W. (2023). Landscape restoration and greening in Africa. Environmental Research Letters, 18(6), 064020. https://doi.org/10.1088/1748-9326/acd395

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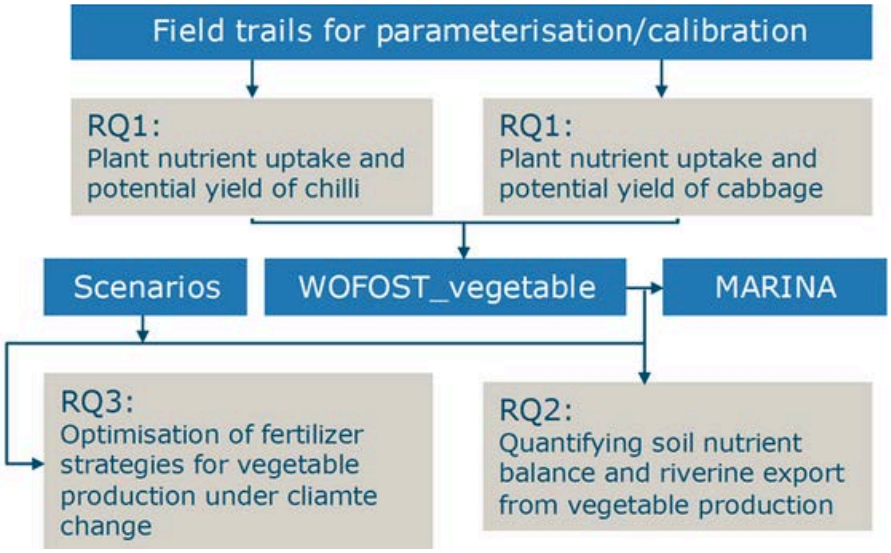
Green development of vegetable production in Yangtze basin

Research challenges

The aim of this project is to evaluate innovative fertilizer strategies to improve nutrient use efficiency in the vegetable system of Yangtze River basin now and under future climate change.

Methods



Results (expected)

- Develop two vegetable versions (chili pepper & Chinese cabbage) of WOFOST in Yangtze River basin to realistically estimate their potential yield and nutrient uptake status.
- Use the coupled WOFOST and MARINA models to quantify the nutrient leaching from soil and riverine nutrient export from vegetable production system in Yangtze River basin.
- Explore alternative fertilizer strategies under future climate change that can safeguard yield and reduce pollution in Yangtze River basin.

Publications

- Modelling growth of chili pepper (Capsicum annuum L.) with the WOFOST model
- Ruoling Tang, Iwan Supit, Ronald Hutjes, Fen Zhang, Xiaozhong Wang, Xuanjing Chen, Fusuo Zhang, Xinping Chen (2023) Agricultural Systems

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Seasonal climate forecasting towards agricultural sustainability in Mainland Southeast Asia

Research challenges

The research focuses on exploring the climate impact on Mainland Southeast Asia and potential applications of seasonal forecasts for both hydrological and agricultural purposes. Specifically, the aim is to investigate the feasibility of utilizing seasonal forecasts as an early warning system. The goal is to contribute to climate adaptation strategies in the region.

Methods

The study will assess the performance of the seasonal climate forecast ECMWF System5 (SEAS5). The application of SEAS5 on the VIC hydrological model and the WOFOST crop model will be evaluated. Subsequently, adaptation strategies based on the climatology, hydrology, and agricultural results derived from SEAS5, the VIC, and the WOFOST model will be provided.

Results (expected)

The performance of the seasonal forecasting system (SEAS5) over Mainland Southeast Asia will be revealed.

The potential applications of seasonal forecasts for both hydrological and agricultural purposes will be presented.

Publications

Analysis of seasonal climate and streamflow forecasts performance for Mainland Southeast Asia (Preprint) https://doi.org/10.5194/hess-2023-56

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Seasonal predictions and agro-hydrological modelling in the Chaco Region, Argentina.

Research Challenges

- Climate risk and seasonal forecasting tailored to Chaco region
- Improving hydro-meteorological data accessibility and homogeneity in Chaco region, Argentina
- Integrating advanced technological tools and crop modelling
- Stakeholder engagement and knowledge transfer
- Developing digital support platforms for decision-making

Methods

- Historical meteorological data from Chaco region sites will be compared with observations from existing stations, supplemented by climate reanalysis datasets if necessary.
- ENSO Phase Analysis: Historical distribution of ENSO phases will be determined using NOAA's operational definitions, evaluating observational data and reanalysis methods' performance in simulating ENSO and its impact on meteorological variables.
- Seasonal Forecast Evaluation: Long and middle range meteorological forecasts will be evaluated for accuracy and reliability, comparing hindcasts with observational and reanalysis data.
- Agro-hydrological Modeling: The SWAP-WOFOST model will be used to predict crop yields and soil moisture variability, incorporating seasonal forecasts and satellite data for validation.
- Platform Development: Insights from previous steps, along with stakeholder engagement, will inform the development of a scalable climate service platform for climate and crop production risk assessment in the Chaco Region, tailored to user requirements through a participatory process.

Results (expected)

Suitable seasonal prediction for crop production for the Chaco region and set- up of Agricultural risk platform

Publications

PROYECTO: RG-T3387-P002 - ATN/RF-17245-RG “Sistema de Asesoramiento al Regante (SAR): ¿cuándo regar y cuánto regar? Las Tecnologías de Información y Comunicación (TICs) como herramientas para fortalecer la capacidad de la toma de decisiones de la agricultura familiar” AgTech_19037-producto_16.pdf (fontagro.org)

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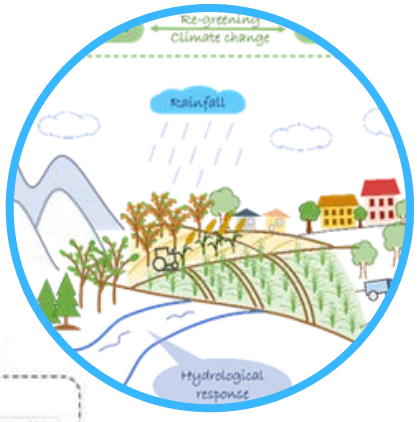
Re-greening rural areas in the Yangtze basin

Research challenges

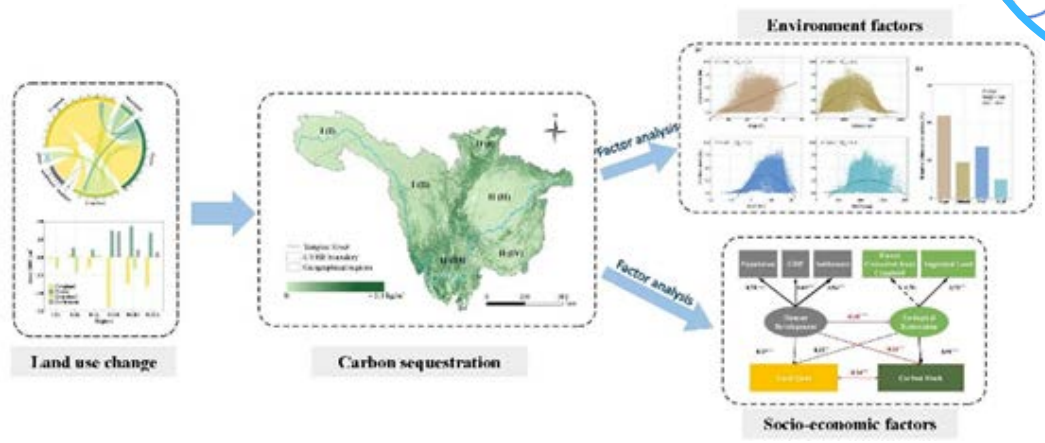
Regreening has been recognized as an effective method for mitigating climate changes. By afforestation and reforestation, carbon can be sequestered in soil and vegetations. This kind of strategy alters land use patterns and influences carbon and water cycle. However, the changing climate conditions may alter the potential of carbon sequestration. Therefore, understanding the joint influences of climate change and land use changes on carbon sequestration and water resources, and tradeoffs amongst these two is of importance in forestation management.
This project focuses on the joint effects of land use change and climate change on Yangtze River Basin China, where large-scale of regreening projects have been implemented.

Methods

- Modelling work combined with remote sensing data are involved in the study.
- Dynamic Global Vegetation Models, represented by the Lund-Potsdam-Jena managed Land (LPJmL).
- Machine learning models for following analysis of outputs.



Results (examples)



- The results indicated positive effects of ecological activities on UYRB, despite decreases in cropland;
- Over the past 20 years, UYRB has sequestered carbon by a total amount of 1796 ± 926 Mt C. However, the ecological effects on total carbon sequestration are limited;
- Agricultural production and carbon sequestration have been enhanced synergically by improved farmland management.

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AGD program:

More information:

- https://doi.org/10.1016/j.jenvman.2023.119376
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5.5

Research projects

Nutrients, Food and Environment (NFE)

Research theme 1: Food production in response to Nutrient and Water availability.

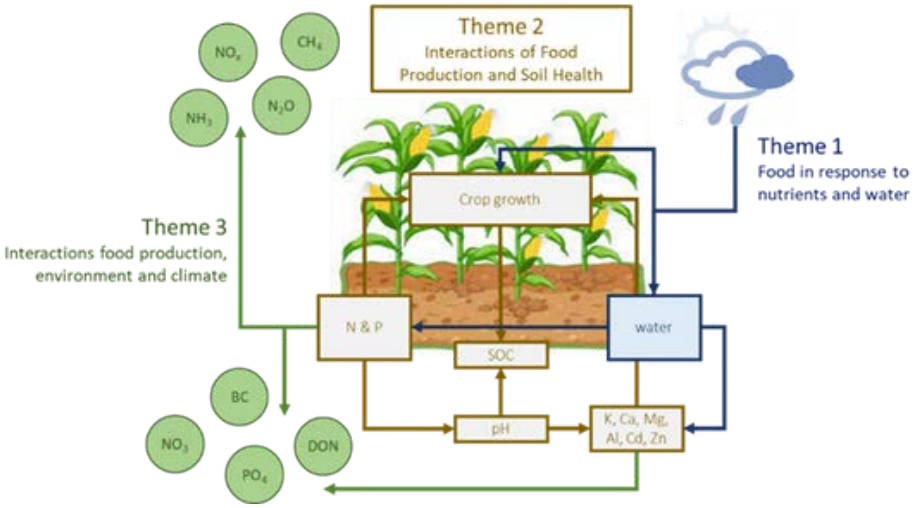
Research Challenges

Nutrient and water availability are interconnected to sustain sufficient and healthy food production. Additionally, nutrients interact in various ways, with synergistic or antagonistic effects on crop yield, underscoring the complexity of their relationship in agricultural systems. Currently there is a lack of quantification of the interactions between nutrient and water availability in crop production at regional and global scales. And there are limited nutrient models that consider impacts of all major and minor nutrients (N, P, K, Ca, Mg, S, Cu Zn, Fe, Mo, B) on crop yield.

Methods

We aim to identify optimal strategies for sustainable agriculture where soil, crop, fertilizer, and water management are well adjusted to site conditions to enhance capacity of soils for healthy crop production and long-term soil quality. Key methods include:

- Identifying key site properties that influence water and nutrient dynamics in agriculture for optimal crop growth
- Designing spatial and temporal optimisation approaches to solve water or nutrient deficiencies and enhance crop yield.
- Developing crop response functions for water/nutrient effects and their interactions, integrating into WOFOST-VIC for impact analysis on yield and water requirement.



Publications

1.Siatwiinda, S.M., I. Supit, B. van Hove, O. Yerokun , G.H. Ros and W. de Vries, 2021. Climate change impacts on rainfed maize yields in Zambia under conventional and optimized crop management. Climatic Change 167:39.

2.Young, M., G.H. Ros and W. de Vries, 2021. A decision support framework assessing management impacts on crop yield, soil carbon changes and nitrogen losses to the environment. Eur J Soil Sci. 72: 1590–1606.

3. Siatwiinda, S.M. G.H. Ros, O.A. Yerokun and W. de Vries, 2024. Options to reduce ranges in critical soil nutrient levels used in fertilizer recommendations by accounting for site conditions and methodology. A review. Agronomy for Sustainable Development (in press).

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Research theme 2. Interactions between Food Production and Soil health.

Research Challenges

Soil health plays a crucial role in crop production. Apart as a growing medium for crops, healthy soils support essential ecosystem services, such as water purification, carbon sequestration, and nutrient cycling. We focus on impacts of measures on flows and pools of carbon, major nutrients (N, P, K, Ca, Mg and S) and metals/minor nutrients (Cu, Zn, Cd, Fe, Mo, B) and their interactions with soil properties, and related soil functions. The research challenges that we tackle are:

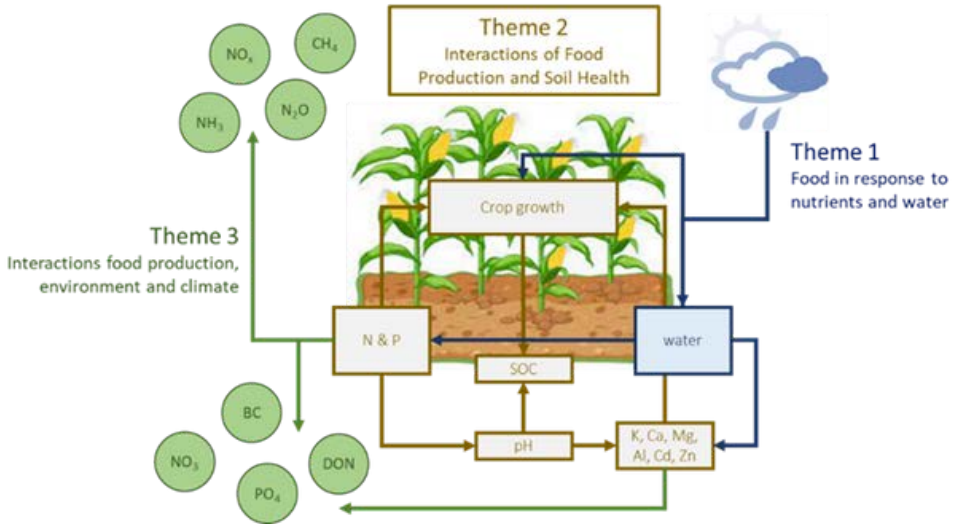
- Developing methodologies to assess impact of soil measures on soil health indicators on regional, national or global scale.
- Optimizing agronomic measures in space and time to improve soil health.

Methods

We focus on further developing integrative assessment frameworks to quantify impacts of measures on soil health indicators by implementing:

·models that assess impacts of soil, crop, and water management on soil properties and crop yield

- "distance-to-target" approaches for soil properties and crop yield
- spatial and temporal optimisation approaches for agronomic measures



Results (expected)

Results since 2021 include papers focusing on the large-scale spatial variation in impacts of nutrient, soil and crop management on soil levels, soil pools and flows of carbon, nutrients and metals and their potential to reduce the gap between current levels and target levels or critical levels of these element.

Publications

Selected publications since 2021 include

1. Lessmann, M., G.H. Ros, M.D. Young and W. de Vries, 2022. The global potential of agricultural management measures on soil carbon sequestration in crop lands. Global Change Biology 28: 1162–1177

2. Xu, D., G. H. Ros, Q. Zhu, M. Xu, S. Wen, Z. Cai, F.S. Zhang and W. de Vries, 2024. Major drivers of soil acidification over 30 years differ in paddy and upland soils in China. Science of the total Environment 916, 2024, 170189 857.

3. You, L., G.H. Ros, Y. Chen, Q. Shao, M. Young and W. de Vries, 2023. The global mean nitrogen use efficiency in croplands can be enhanced to 70% by optimal nutrient, crop and soil management practices. Nature Communications 14, 5747

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Research theme 3. Interactions between Food Production and Environment

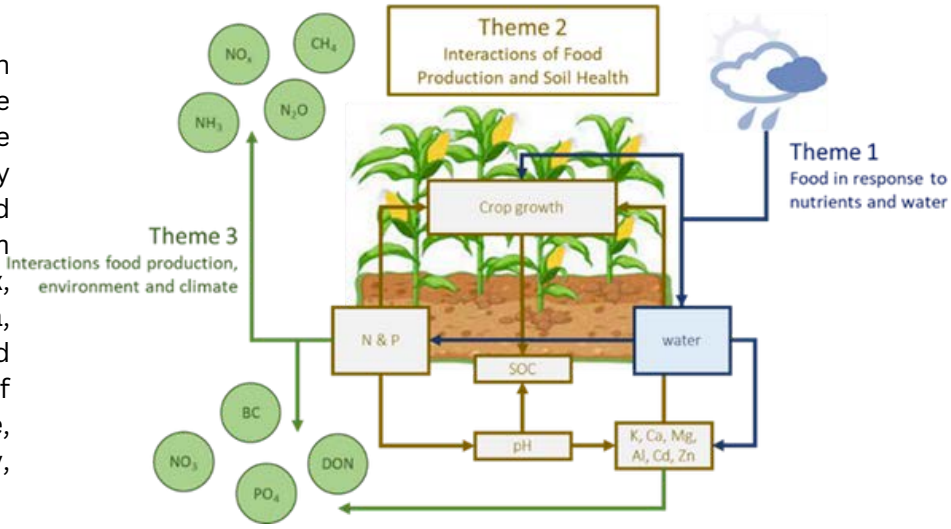
Research Challenges

In the search for optimum land use practices one have to deal with the balance between food production and losses of nutrients and greenhouse gases to air and water. Achieving this delicate balance requires innovative and novel methods to address the:

- Interactions and trade-offs among different nutrients and among livestock and cropland to increase the use efficiency and reduce environmental trade-offs.
- Desired status (e.g. critical inputs, surpluses or losses) for nutrients.
- Impacts of management practices on closing the gap between current and desired status

Methods

In accordance with the approach in theme 2, we focus on the development of integrative assessment frameworks to quantify the fate of carbon, nutrient and pollutants in the agricultural system in view of losses to air (NH3, NOx, N2O, CO2, CH4), and water (N, P, Ca, Mg, K, S) and derive critical loses and surpluses or inputs in view of environmental impacts on climate, terrestrial and aquatic biodiversity, and human health.



Results (expected)

Results since 2021 include papers focusing on an assessment of the large-scale spatial variation in current, critical and target nutrient and metals inputs and impacts of nutrient, soil and crop management on nutrient use efficiencies and losses of nitrogen, phosphorus and greenhouse gases to air and water.

Publications

Selected publications since 2021 include:

1. Chang, J., P. Havlík, D. Leclère, W. de Vries, H. Valin, A. Deppermann, T. Hasegawa and M. Obersteiner, 2021. Global food security risks associated with meeting regional nitrogen boundaries. Nature Food 2: 700–711.

2. De Vries, W., J. Kros, J.C.H. Voogd, G. Louwagie and L. F. Schulte-Uebbing, 2021. Spatially explicit boundaries for agricultural nitrogen inputs in the European Union to meet air and water quality targets. Science of the total Environment 786 147283.

3. Gu, B., X. Zhang, S. K. Lam, Y. Yu, J.J.M. van Grinsven, S. Zhang, X. Wang, B.L. Bodirsky, S. Wang, J. Duan, C. Ren, A.F. Bouwman, W. de Vries, J. Xu, M.A. Sutton, D. Chen, 2023. Cost-effective mitigation of nitrogen pollution from global croplands. Nature 613: 77–84.

4. Schulte-Uebbing, L.F., A.H.W. Beusen, A.F. Bouwman and W. de Vries, 2022. From planetary to regional boundaries for agricultural nitrogen pollution. Nature 610: 507–512.

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Assessing optimal nutrient management practices in view of agronomic and environmental impacts

Research Challenges

Agricultural management practices influence many agronomic, soil, and environmental indicators related to crop production, soil quality, and air and water quality. Current agricultural practices often focus on crop production, which may lead to increased nutrient losses to air and water with negative effects on the environment such as soil acidification, pollution of water bodies and eutrophication, and loss of biodiversity. A complete (semi-)quantitative overview of the impacts, including co-benefits or trade-offs, of multiple management practices on multiple indicators, while accounting for the spatial variation in impacts due to differences in site conditions will be carried out.

Methods

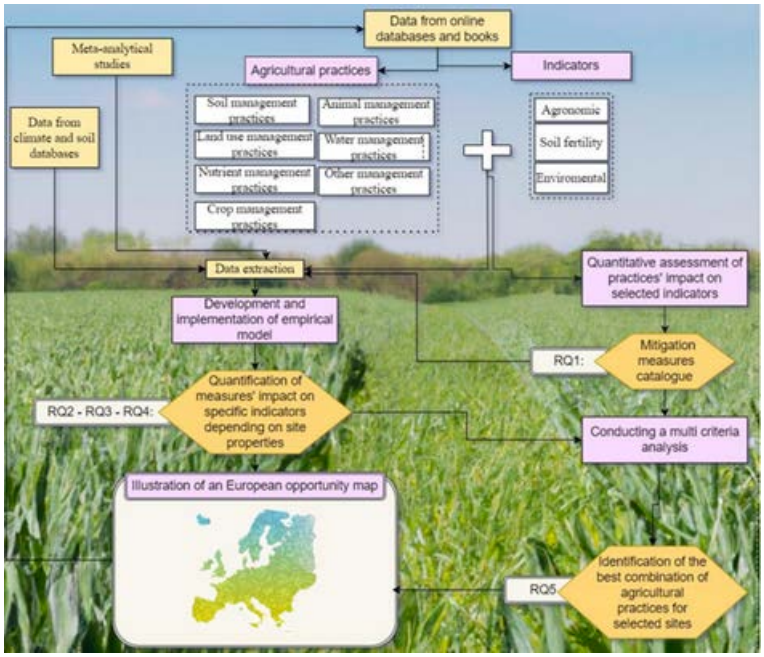
Methods include:

1.Creation of a catalogue of agricultural practices that are utilized in three different farming systems (conventional, organic and agroecological)

2.Meta-analyses to assess the impact of those practices on crop yield, NUE, PUE, soil pH, base saturation, and greenhouse gas emissions while accounting for site properties (texture, pH, climatic variables).

3.Multi-criteria analysis to assess the optimal combinations of agricultural practices.

The anticipated result will be an opportunity map presenting the optimal combination of agricultural practices among different European regions to bridge the gap between the actual and the desired state of crop yield, soil quality (nutrient) indicators and environmental indicators.



Results (expected)

The (expected) results include 5 papers on:

1.Impacts of agricultural practices on agronomic, soil fertility and environmental indicators as a function of site conditions

2.Impacts of agricultural practices on nutrient use efficiencies and related crop yields in European agriculture

3.Impacts of a management practices on soil pH and base saturation in European agricultural soils

4.Impacts of management practices on greenhouse gas emissions from peat soils under agriculture in Europe

Spatial optimization of management practices in view of their impacts on crop yield, soil fertility and environment

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Combined field and model-based approaches for large scale sustainable phosphorus management

Research Challenges

Use of phosphorus (P) fertilizer in excess of crop P demand has caused significant P accumulation in agricultural soils, with a related increase in soil P fertility but also an enhanced risk for P leaching and P runoff, causing eutrophication of surface water. Sustainable P management, implies that P application should be less, equal or higher than crop removal when available soil P levels are respectively above, equal or lower than critical soil P test levels. However, traditional soil P tests do not well the soil P buffer capacity (PBC) affecting the long-term effects of P addition on crop P uptake and soil P changes. The main aim of this project is to identify spatially explicit sustainable P management strategies at county level in China based on a soil P test including P buffer capacity.

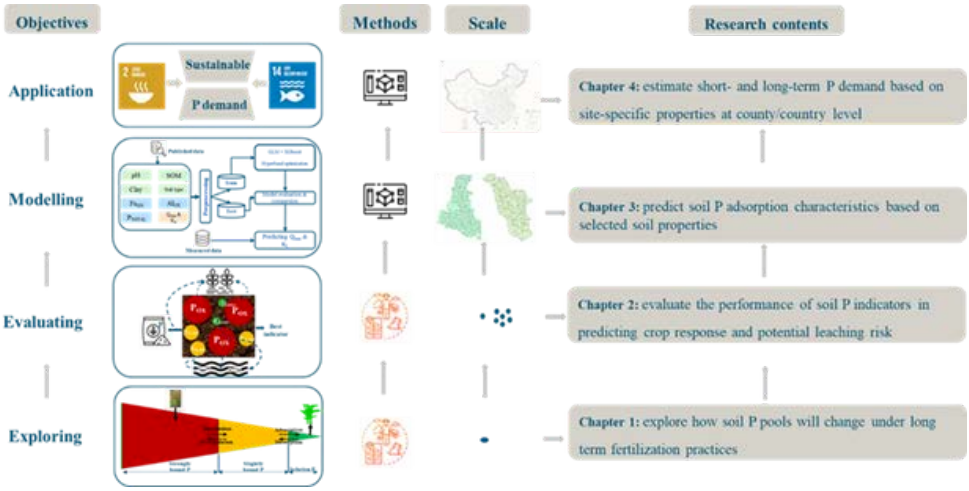
Methods

Methods include a combination of field experiments, literature reviews, empirical modeling, machine learning and process-based large scale modelling to:

1.explore the relationship between phosphorus (P) inputs, changes in reactive and dissolved soil P pools, and crop P uptake.

2.assess the link between soil P buffer capacity and P affinity constants and soil characteristics

quantify spatially explicit sustainable P management strategies, bringing the soil P status to an adequate level, illustrated for the Quzhou and Qiyang counties in China.



Results (expected)

Expected result include

1.Quantification of the changes in different soil phosphorus (P) pools and crop P uptake under long-term P input

2.Evaluation of the P saturation degree as a soil P indicator for both crop yield and P leaching risk

3.Maps of the soil P sorption capacity and P sorption affinity of Chinese soils (county level)

4.Target P inputs at the county level based on soil P sorption characteristics at the county level to bring soils to target P levels to maximize crop yield and minimize leaching risk

Publications

Gu, Y., G. H. Ros, Q. Zhu, D. Zheng, J. Shen, Z. Cai, M. Xu and W. de Vries, 2023. Responses of total, reactive and dissolved phosphorus pools and crop yields to long-term fertilization. https://doi.org/10.1016/j.agee.2023.108658

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mitigation of ammonia emissions and its impact on greenhouse gas and reactive nitrogen emissions in an integrated crop-poultry system.

Research Challenges

Feeding the growing and increasingly affluent population in China has causes a strong increase in livestock production, concurrent with a decoupling of crop-animal production systems. The separation of livestock systems from crop systems, in combination with improper manure management, has caused enhanced nitrogen (N) losses into air and water bodies, adversely affecting human and ecosystem health, and increased direct and indirect N2O emissions and CH4 emissions, contributing to climate change. This project aims to explore the mitigation potential of recoupling poultry systems with local cropland and enhancing improved practices in the manure management chain on nitrogen losses and greenhouse gas emissions.

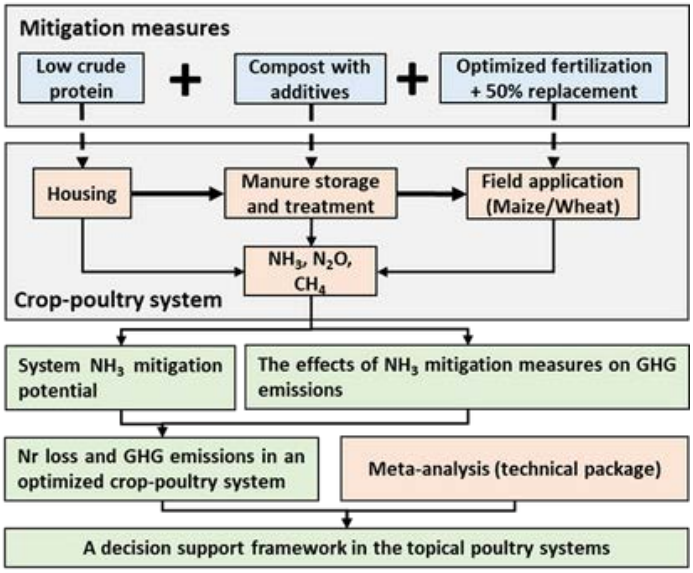
Methods

Data from a large scale in situ experiment in a typical poultry system , carried out Quzhou County, combined with a literature review, are used to:

1.Assess the impact of NH3 mitigation measures at housing, manure storage and treatment, and field application stages on NH3 emissions.

2.Assess the accompanying impacts on reactive nitrogen losses and greenhouse gas emissions

Develop and apply a framework for reducing reactive nitrogen losses and non-CO2 greenhouse gas emissions.



Results (expected)

Result include papers on the:

1.Quantification of the NH3 mitigation potential in crop-poultry systems

2.Evaluation of the impacts of NH3 mitigation measures on greenhouse gas emissions in crop-poultry systems

3.Quantification of the response of reactive nitrogen losses and greenhouse gas emissions to NH3 mitigation measures

4.Establishment of a framework to reduce reactive nitrogen losses and greenhouse gas emissions in typical poultry systems

Publications

1.He, Z., Y. Zhang, X. Liu, W. Xu, Y. Hou, H. Wang and F. S. Zhang, 2022. Ammonia mitigation potential in an optimized crop-layer production system.Science of The Total Environment 841, 1 156701. https://doi.org/10.1016/j.scitotenv.2022.156701

2.He, Z., Z. Xia, Y. Zhang, X. Liu, W. de Vries, G.H. Ros, O. Oenema, W. Xu, Y. Hou, H. Wang and F.S. Zhang, 2023. Ammonia mitigation measures reduce greenhouse gas emissions from an integrated livestock-cropland system in China. Journal of Cleaner Production 422, 2023, 138561. https://doi.org/10.1016/j.jclepro.2023.138561

3.He, Z., Y. Zhang, X. Liu; W. de Vries, G. H Ros, O. Oenema, W. Xu, Y. Hou, H. Wang, F.S. Zhang, 2023. Mitigation of nitrogen losses and greenhouse gas emissions in a more circular cropping-poultry production system. Resources, Conservation & Recycling 189 106739. https://doi.org/10.1016/j.resconrec.2022.106739

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Sustainable phosphorus inputs at the global and regional scale in view of crop yield and water quality

Research Challenges

An historical excess of phosphorus (P) fertilization in industrialized countries has led to P-saturated soils and correspondingly to eutrophication of waterbodies due to enhanced P losses from soil to water through subsurface flow and runoff. This research focuses on approaches to define and derive sustainable P inputs, considering that P resources are finite .balancing crop yield and environmental P losses at different spatial scales (Netherlands, Europe and world).

Methods

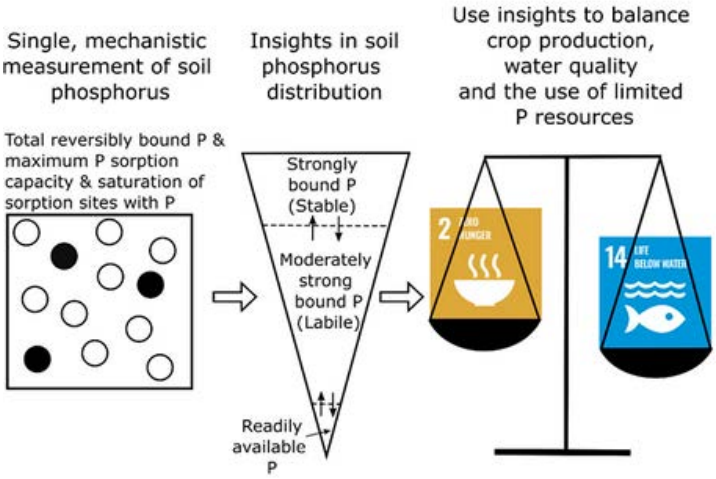
The methods to be used will be a combination of literature reviews, digital soil mapping, modelling and machine learning to:

1.Identify a soil P test for routine agronomic protocols which fits the challenge to balance crop production, water quality and the use of finite P resources in agriculture.

2.Produce high-resolution maps of the maximum P sorption capacity of soil at national, continental and global scale.

3.Improve the spatially heterogeneity of P sorption in current global soil P models (IMAGE-DPPS)

4.Derive target P inputs at the Dutch, European and global scale in view of crop production and water quality



Results (expected)

1.Illustration of the potential of the P saturation degree, being the ratio of oxalate-extractable P and the maximum P sorption capacity, as a universal agri-environmental soil P test, which is best to assess medium-term and long-term sustainable P inputs.

2.Digital Soil Maps of the maximum P sorption capacity, specifically of soil amorphous iron- and aluminium-(hydr)oxide contents for the Netherlands and Europe.

3.High-resolution maps of the maximum P sorption capacity of soils using machine learning techniques and incorporation of those maps in the global P models (IMAGE-(G)DPPS).

4. Provision of pathways to balance crop production, water quality and the use of finite P resources in fertilizer recommendations by making use of improved models, digital soil maps of the maximum P sorption capacity.

Publications

Van Doorn, M., van Rotterdam, D., Ros, G., Koopmans, G. F., Smolders, E., and de Vries, W. (2023). The phosphorus saturation degree as a universal agronomic and environmental soil P test. Critical Reviews in Environmental Science and Technology, 0(0):1–20. https://doi.org/10.1080/10643389.2023.2240211

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Potential of agricultural management strategies to minimize the gap between current and critical ammonia emissions in China

Research Challenges

Excessive agricultural nitrogen (N) use not only affects water quality by leaching and runoff of nitrate, but also air quality by enhanced emission of ammonia (NH3). Emissions and related deposition of ammonia and ammonium, in combination with nitrogen oxides from industry and traffic, causes eutrophication and acidification of terrestrial ecosystems, posing a threat to biodiversity. The aim of this research is to: (i) develop and apply methodologies to produce high spatial resolution maps of current and critical NH3 emissions in China and (ii) evaluate effects of spatially targeted ammonia emission mitigation strategies to close the gap between current and critical NH3 emission.

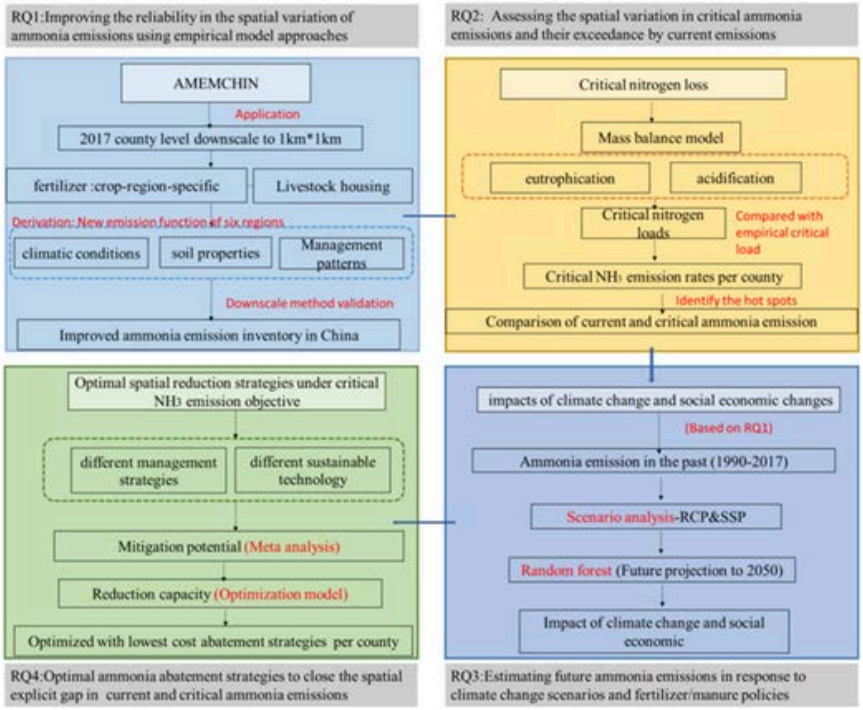
Methods

Methods include:

1.An empirical model for a high-resolution ammonia emission inventory for cropland and livestock management in China

2.A methodology to assess critical ammonia emissions from critical nitrogen loads, accounting for spatially explicit differences in ammonia and NOx deposition and in agricultural areas.

3.A methodology to assess the effects of varioustechnological innovations and management measures on NH3 emissions including economic (costs), institutional aspects (e.g., local Governmental support) and social aspects (e.g., farmers' willingness to change the current practice).



Results (expected)

Expected results include four publications on:

(i) Spatial patterns of current ammonia emissions using a newly developed bottom-up method in China.

(ii) Gaps between current and critical agricultural ammonia emissions for terrestrial ecosystems in China

(iii) Projected agricultural ammonia emissions in response to different climate change scenarios and fertilizer policies in China.

(iv) Optimal spatial reduction strategies to reduce the gap between current, projected and critical ammonia emissions in China.

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Optimization of spatial manure recycling strategies in view of economic and environmental impacts in Chinese agriculture

Research Challenges

Due to the rapid growth of the crop and livestock industry, China consumes about one-third of global nitrogen (N) fertilizer and 21% of global phosphorus (P) fertilizer. Currently, the average manure-recycling ratio is approximately 40% in China, implying that 60% of the manure nutrients are lost to the environment. Replacing mineral N and P fertilizer inputs by manure would reduce soil acidification, since manure contains significant amount of base cation nutrients. Recoupling livestock and cropland on a regional scale could thus both reduce manure N and P losses in the entire food chain and soil acidification rates. The main research challenge in this project is to build a manure allocation model to evaluate and optimize spatially specific manure recycling and manure allocation strategies in view of environmental and economic cost and benefits.

Methods

The methods in this project involve

1.material flow analysis to quantify the spatial variability in regional nutrient balances the nutrient balances (inputs and crop uptake) and the impacts of changes in livestock numbers, crop structure and manure treatment technologies on those regional nutrient balances nutrient losses

2. a model approach, combined with a cost-benefit analysis, to quantify the costs and benefits of different manure recycling strategies and optimize regional manure allocation strategies.

Results (expected)

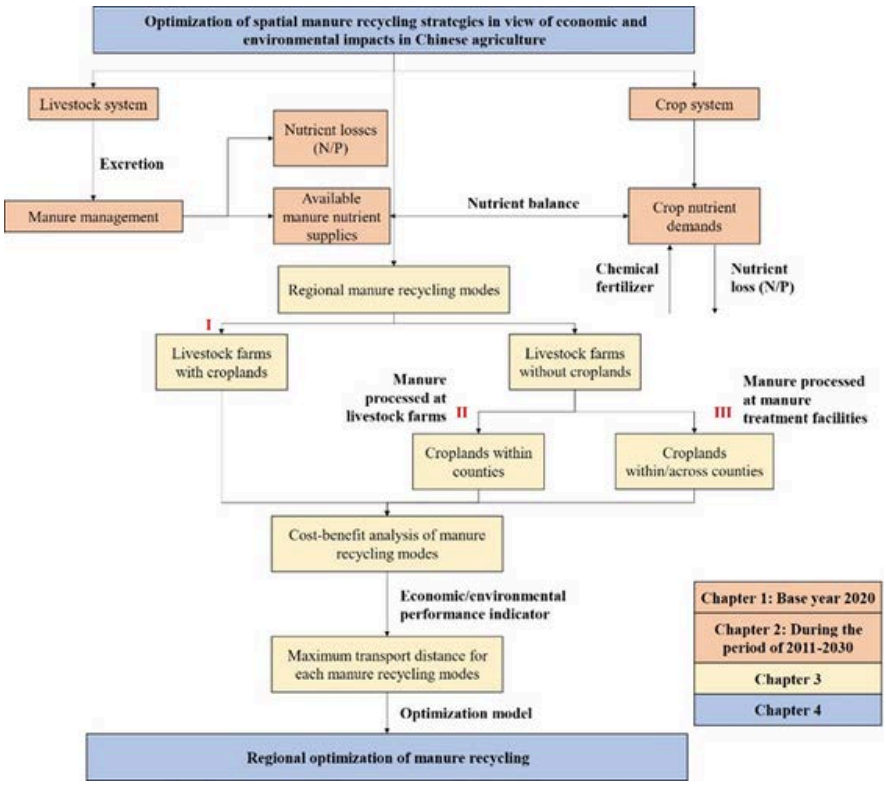
Expected results included papers on

1) the spatial variability in crop nutrient demands and manure nutrient supplies under current crop production (base year 2020)

2) changes in the manure nutrient supply and nutrient losses in response to changes in livestock numbers, manure recycling rates and manure treatment technologies over the period 2011-2030

3) the environmental impacts and economic costs and benefits of different manure recycling strategies in terms of crop and livestock farmers' income and losses of nitrogen (N), phosphorous (P) to air and water

4) a regional optimization model to optimize manure allocation strategies



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Sustainable management of large-scale soil acidification and cadmium mobilization in Chinese croplands

Research Challenges

Soil acidification is associated with various conditions restricting crop growth and enhances cadmium (Cd) bioaccumulation in crops and animals, threatening food safety and human health. Currently, around 40% of arable land in China is affected by soil acidity, mainly caused by improper agricultural management such as overuse of nitrogen fertilizer. This project aims to develop sustainable soil acidity management options by assessing: (i) the spatio-temporal variation of soil acidification of croplands in response to fertilization management (ii) the impacts of nutrient management scenarios on soil acidification and Cd crop uptake and (iii) optimal nutrient management to avoid soil acidity-induced yield losses and Cd uptake of main cereal crops, focusing on the county Qiyang in China.

Methods

Methods include

1. calibration and application of the soil acidification model VSD+ by comparing simulated and observed soil pH values in a long term fertilization experiment and predict the spatial and temporal variation of soil acidification rates and required lime applications at county scale.
2. Development of a dynamic Cd mass balance model, coupled to VSD+, to assess soil Cd changes and related impacts on crop yield and crop quality at county scale in response to nutrient management
3. Development and application of a site-specific integrated mitigation strategy tool to assess the optimal application of mineral and organic fertilizers and lime to reduce soil acidification and minimize the nitrogen and phosphorus surplus.

Results (expected)

Expected results included publication on

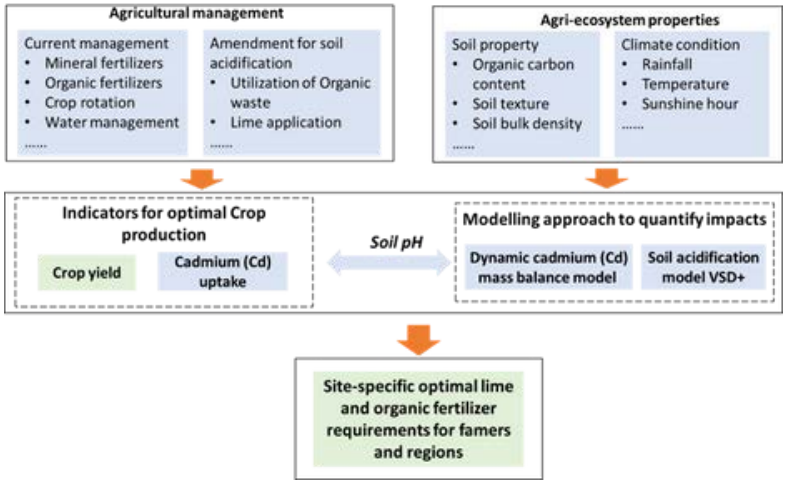
1.Optimal management strategies to mitigate cropland acidification at a long-term fertilization experiment in Qiyang County

2.Spatially explicit amounts and intervals of agricultural lime applications at county-level

3.Impacts of various nutrient management scenarios on cropland soil acidification at county-level

4.Optimization of lime and organic manure application to avoid soil acidity-induced yield loss and minimize N and P surpluses

Optimization of lime and organic manure application to avoid both soil acidity-induced yield losses and cadmium (Cd) uptake



Publications

1.Xu, D., G.H. Ros, Q. Zhu, M. Xu, S. Wen, Z. Cai, F. Zhang and W. de Vries, 2024. Sci. Tot. Environ.

2.Xu, D., Q. Zhu, G.H. Ros, M. Xu, S. Wen, F. Zhang and W. de Vries, 2023. Model-based optimal management strategies to mitigate soil acidification and minimize nutrient losses for croplands. Field Crop Research 292, 108827.

3.Xu, D., Q. Zhu, G.H. Ros, Z. Cai, S. Wen, M. Xu, F. Zhang and W. de Vries, 2021. Calculation of spatially explicit frequency and quantity of agricultural lime applications in Qiyang County, China. Science of the Total Environment 806, 150955.

4. Xu, D., A. Carswell, Q. Zhu, F. Zhang and W, de Vries, 2020. Modelling long-term impacts of fertilization and liming on soil acidification at Rothamsted experimental station. Science of the total Environment 713. 136249.

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Sustainable management of large-scComprehensive improvement of soil acidification in typical crop systems of Chinaale soil acidification and cadmium mobilization in Chinese croplands

Research Challenges

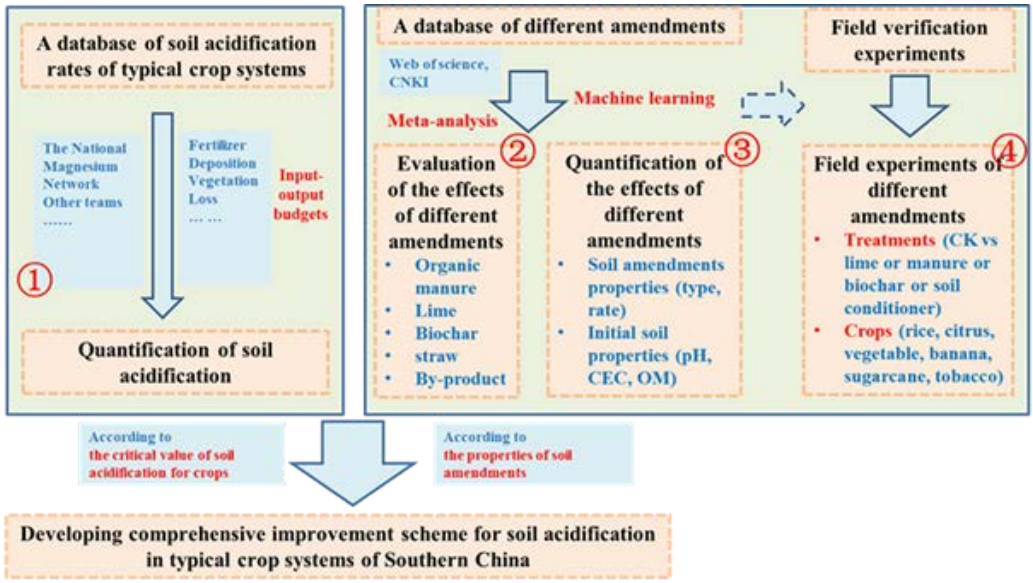
The increased food demand in China as resulted in excess use of nitrogen (N) fertilizer, causing enhanced nitrate leaching and of soil acidification in major Chinese cropland systems. Currently, around 40% of China's arable land is affected by soil acidity, being a threat to crop yields in some areas of China. Effective management to alleviate soil acidification on Chinese croplands is thus important for sustainable agriculture development. The objectives of the project are to develop a scheme for reducing soil acidification of typical crop systems based on the current acidification risk status and the mitigation effect of amendments for different crop systems in southern China.

Methods

1.Quantification of soil acidification rates of typical crop systems in China by integrating farmer questionnaires, official statistical data and published literature on nutrient inputs and outputs.

2.Performance of a meta-analysis to quantify the effects of different amendments on soil acidity (pH, base saturation and cation exchange capacity) and crop yields.

3. Development of a comprehensive improvement scheme for soil acidification in typical crop systems of southern China,.



Results (expected)

1.Current and potential soil acidification risks for typical crops in southern China

2.Effects of different amendments on soil properties, focusing on soil pH, and crop yield using meta-analysis

3.An empirical model to quantify the effects of lime, biochar and manure addition on soil pH as a function of amendment rate and soil properties

4. Mitigation strategies of soil acidification based on classified risk control in Chinese croplands

Publications

Zhang, S., Zhu, Q., de Vries, W., Ros, G., Chen, X., Muneer, M.A., Zhang, F., Wu, L., 2023. Effects of soil amendments on soil acidity and crop yields in acidic soils: A world-wide meta-analysis. J. Environ. Manage. 345, 118531.
https://doi.org/10.1016/j.jenvman.2023.118531

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Impacts of management, climate and soil properties on nitrogen use efficiency and soil acidification in croplands in China

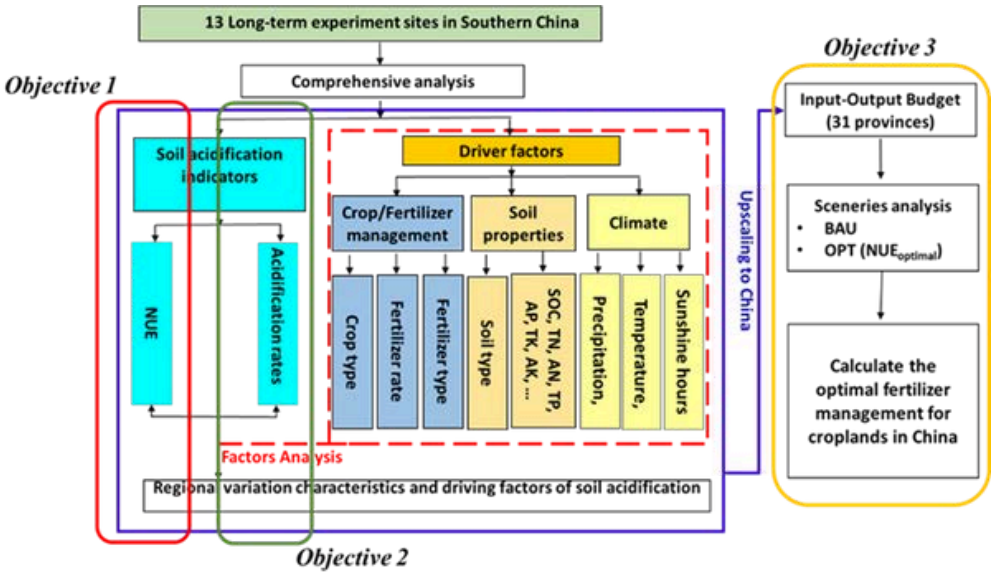
Research Challenges

Soil acidification causes a decline in soil pH and related soil fertility, limiting agronomic yield potential. In China, the excessive use of mineral nitrogen (N) fertilizers contributes to soil acidification due to nitrate leaching, associated with base cation leaching. This effect is significantly influenced by fertilizer management (dosage and type) and climate, impacting both nitrogen use efficiency (NUE) and soil properties that determine the acid-neutralizing capacity (base cation content) of the soil. In comparison to mineral N fertilizer, the application of manure can prevent acidification due to its alkalinity and high base cation content. A systematic examination of the long-term effects of various combinations of mineral N fertilizers and manure on NUE and soil acidification rates can contribute to optimizing fertilizer and manure management, mitigating the adverse impacts of soil acidification.

Methods

1.Quantification of the nitrogen use efficiency (NUE) and soil acidification rates at 13 experimental plots as a function of crop/fertilizer management (crop types, fertilizer rate, fertilizer types), climate (precipitation, temperature and sunshine hours) and soil properties (, soil type, soil organic matter content, total and available contents of N, P and K)

2. Prediction of impacts of different fertilizer and manure management options on N and P surpluses and on soil acidification rates to assess the optimal ratio of manure and fertilizer combinations over China.



Results (expected)

1.Long-term impacts of mineral and organic fertilizer inputs on nitrogen use efficiency for different cropping systems and site conditions in Southern China

2.The contribution of natural and anthropogenic causes of on soil acidification rates under different fertilization practices and site conditions

3. Variations in optimal fertilizer and lime management to counteract soil acidification and minimize nutrient losses for cropland over provinces in China

Publications

Zhu, X., G.H. Ros, M. Xu, Z. Cai, N. Sun, Y. Duan and W. de Vries, 2023. Long-term impacts of mineral and organic fertilizer inputs on nitrogen use efficiency for different cropping systems and site conditions in Southern China. Europ. J. Agronomy 146: 126797. https://doi.org/10.1016/j.eja.2023.126797

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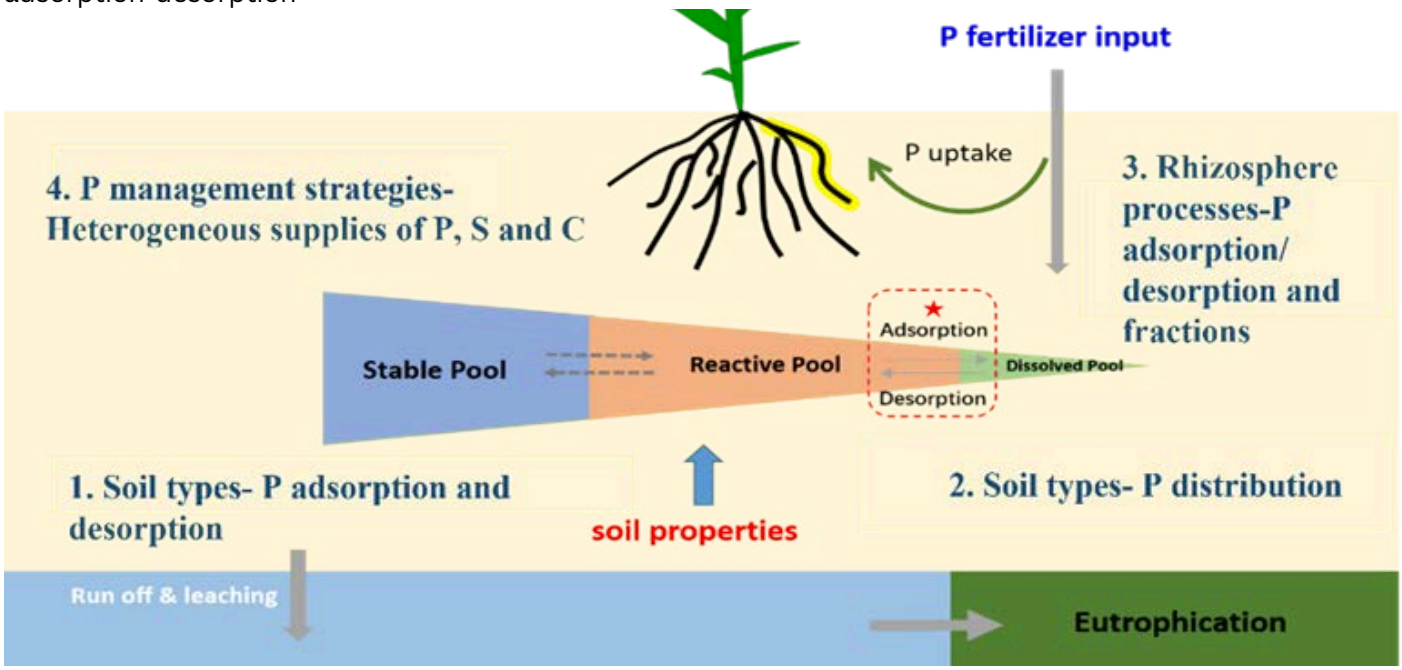
Optimizing P management strategies based on soil P dynamics and rhizosphere processes

Research Challenges

High P (phosphorus) inputs in excess of plant P uptake have caused significant soil P accumulation in China. In order to reduce P fertilizer inputs, soil and plant rhizosphere-based management strategies are needed. To identify the effectiveness of these strategies and assess sustainable P fertilizer needs, insight in impacts of soil properties and rhizosphere on P adsorption-desorption parameters and P fertilizer distribution is crucial. The objective of this project is to identify sustainable P management strategies based on soil P sorption-desorption processes and plant rhizosphere processes in different soil types

Methods

1. Soil incubation experiments to assess the impacts of soil properties on the distribution of added P over dissolved, weakly bound, strongly bound and stable P pools.
2. Adsorption-desorption experiments to assess the impacts of soil properties on P adsorption-desorption parameters
3. In the greenhouse pot experiments to investigate the P dynamics in the rhizosphere in combination with P adsorption-desorption



Results (expected)

1.Changes in dissolved, weakly bound, strongly bound and stable phosphorus pools in response to P addition as affected by soil properties
2.Phosphorus adsorption-desorption characteristics of major soils in China in relation to soil properties
3. Effect of plant rhizosphere processes on soil phosphorus adsorption-desorption and phosphorus fractions

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5.6

Research projects

Water, Climate and Food (WCF)

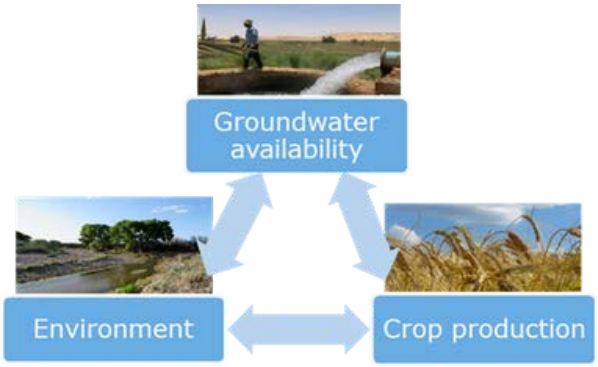
GROW: Groundwater Sustainability and Crop Production

Research challenges

Groundwater is the largest accessible source of freshwater and is of critical importance for humans and the environment. Irrigation is by far the largest user of groundwater worldwide and accounts for 17% of the global cropland area and 40% of the global food production. Currently groundwater is overused in various regions around the world and negative impacts are experienced. To reduce and prevent negative impacts of groundwater overuse, groundwater must be used more sustainably. At the same time, global food demands will rise and crop production has to increase to secure adequate food supply worldwide. A daunting global challenge lies ahead in how to use groundwater sustainable while at the same time sufficient crop production, to support regional and global food security, should be maintained. In GROW we aim to assess **how much groundwater is sustainably available worldwide and to what extent this available groundwater supports sufficient crop production to meet current and future food demands.**

Methods

Integration of global scale groundwater, surface water, and crop growth modelling (see also VIC-WUR development). Including water demands and water uses now and in the future, including adaptation.



Results (Expected)

- Improved quantification of the contribution of groundwater to crop production.
- Improved quantification of the contribution of groundwater to a healthy environment.
- Advanced assessment how much groundwater is sustainably available worldwide and to what extent this available groundwater supports sufficient crop production to meet current and future food demands

Publications

- 1.de Graaf et al. Global Analysis of Groundwater Pumping from Increased River Capture. Environmental Research Letters (in print).
- 2.Mohan, C., T. Gleeson, T. Forstner, J.S. Famiglietti, I.E.M. de Graaf (2023) Quantifying groundwater's contribution to regional environmental flows in diverse hydrological landscapes. Water Resources Research. doi:10.1029/2022/2022WR033153.
- 3.de Graaf, I.E.M. and K. Stahl (2022), A model comparison assessing the importance of lateral groundwater flows at the global scale, Environ. Res. Letters, 17, 044020. doi: 10.1088/1748-9326/ac50d2.
- 4.De Graaf, I.E.M., T. Gleeson, L.P.H. van Beek, E.H. Sutanudjaja, M.F.P. Bierkens (2019), Limits to global groundwater pumping, Nature, 574, 90-94, doi:10.1038/s41586-019-1594-4.

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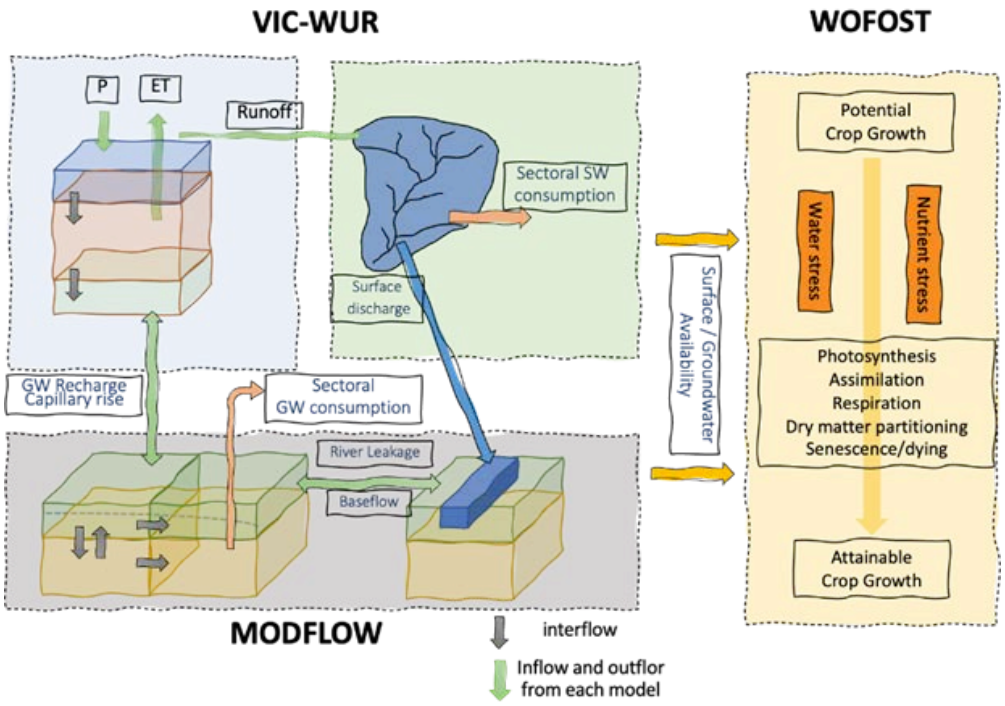
Model development VIC-WUR



Research challenges

In our group we use and develop the VIC-WUR model, which is our version of the Variable Infiltration Capacity (VIC) model. It has been used and developed for 10+ years in the former Water Systems and Global Change group. The VIC-WUR model is unique in solving both the water balance and energy balance at global-to-regional scales. We use our model to better understand and predict current and future impacts of climate change and human water uses.

Recent developments focused on coupling to the crop growth and production model WOFOST [1]. Also a relative simple water demand and water use module has been included [2]

Current developments are focused on:
-Coupling groundwater to hydrology and crop production.
-Moving to high resolution globally (5arcminutes globally)
-Advancing the current water demand and water use module.
-Improving code architecture and streamline the development process (e.g. continuous integration).
-Improving training material and documentation for modelers and MSc students.

Outcomes of the VIC-WUR model are being used by researchers covering the following topics: water quantity, water quality, adaptation, mitigation. With the VIC-WUR model we are part of the ISIMIP Global Water sector and ISIMIP Groundwater sector. Moreover VIC-WUR is part of the Copernicus hydrological seasonal forecast for Europe model ensemble [3].

Results (Expected)

-Advanced and more detailed assessment of freshwater availability now and in the future.
-Advanced assessment of current and future impacts of climate change and human water uses, incl. quantity and quality issues.
Knowledge development aiming on supporting adaptation decisions at regional scale.

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Model development VIC-WUR

Methods

figure: an example of research output generated with VIC-WUR model.

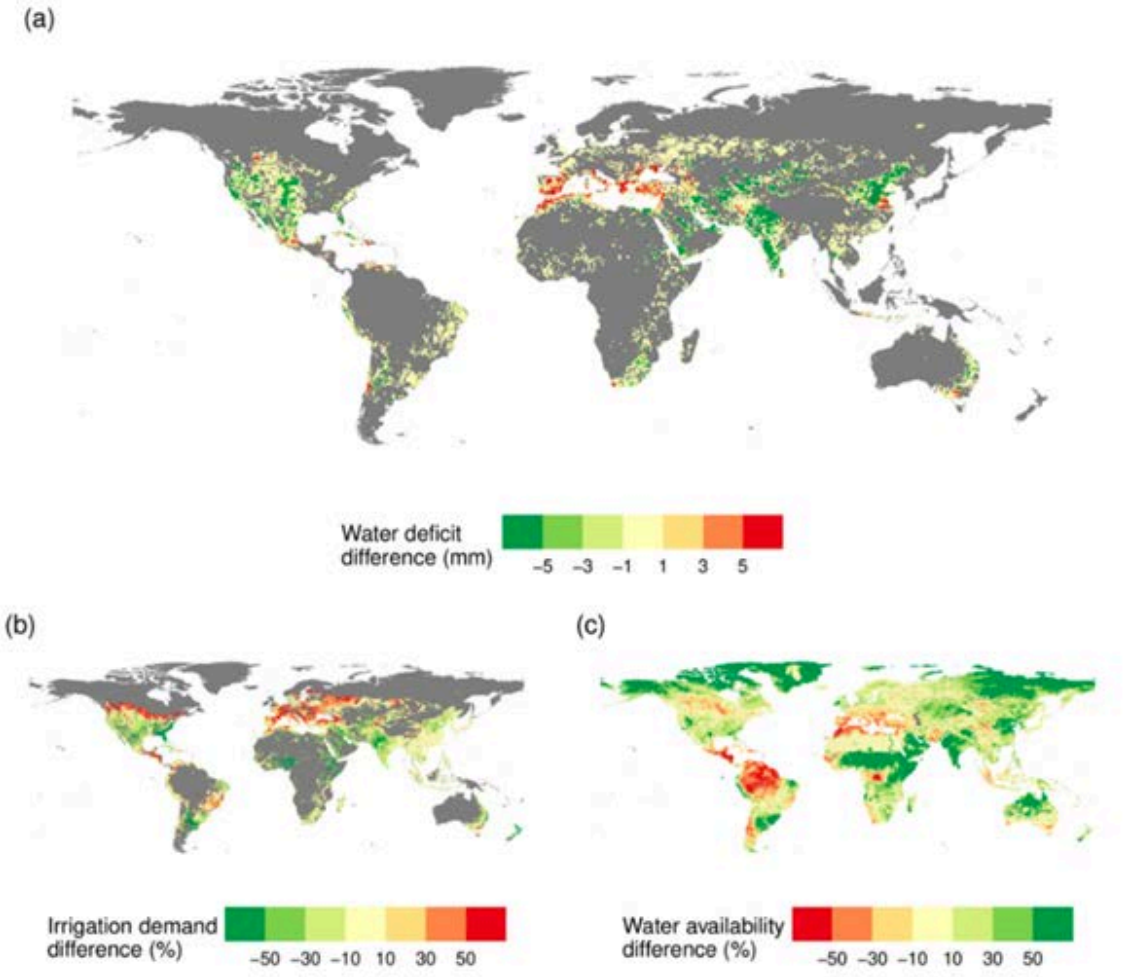

Figure 6.1: Simulated end-of-this-century (2071-2100) annual average difference in (a) water deficit, (b) irrigation demand and (c) water availability under low climate-change mitigation (RCP8.5) compared to 1971-2000. Note that negative water deficit changes do not necessary indicate there no longer is a deficit, only that this deficit decreases.

Publications

[1] Droppers, B., et al. (2022). "Limits to management adaptation for the Indus' irrigated agriculture."
[2] Droppers, B., et al. (2019). "Simulating human impacts on global water resources using VIC-5."
[3] Berg, P., et al. (2021): Multi-model seasonal forecasts of river discharge for Europe from January 2021 to present. Copernicus Climate Change Service (C3S) Climate Data Store (CDS).

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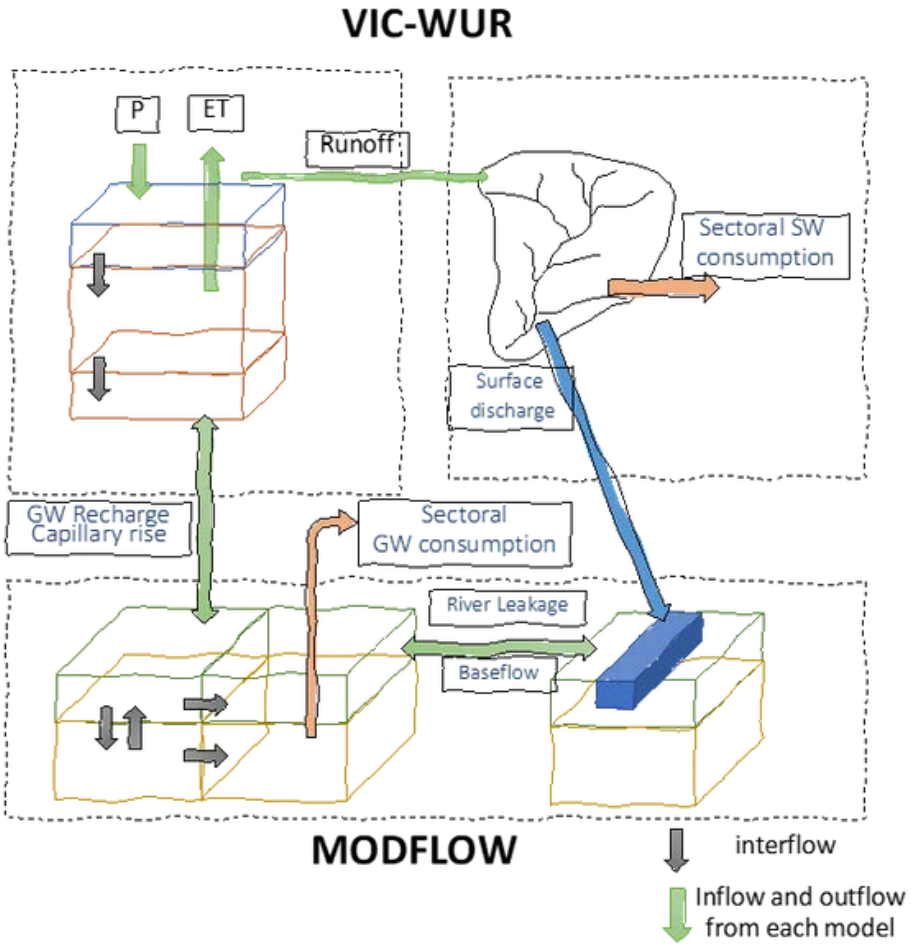
Development and application of the coupled VIC-WUR, MODFLOW and crop growth model

Research challenges

Groundwater significantly influences the hydrological cycle, yet it is often overlooked in hydrological models while assessing the global water availability. My research aims to enhance the VIC-WUR model by integrating it with a groundwater simulation developed through the MODFLOW program [1]

Methods

This integration forms two critical connections: the VIC-WUR model, at each timestep, simulates surface and subsurface processes, supplying inputs of groundwater recharge and surface runoff to the MODFLOW model. Conversely, the MODFLOW model calculates capillary rise flux into the vadose zone and groundwater baseflow, contributing to river flow, which is then fed back into the VIC-WUR model.



Results (Expected)

This integration forms two critical connections: the VIC-WUR model, at each timestep, simulates surface and subsurface processes, supplying inputs of groundwater recharge and surface runoff to the MODFLOW model. Conversely, the MODFLOW model calculates capillary rise flux into the vadose zone and groundwater baseflow, contributing to river flow, which is then fed back into the VIC-WUR model.

Publications

[1] de Graaf, Inge EM, et al. "A global-scale two-layer transient groundwater model: Development and application to groundwater depletion." Advances in water Resources 102 (2017): 53-67.

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Identifying climate adaptation strategies for agri-food value chain actors using hybrid Machine Learning and process-based modelling approaches

Research challenges

Climate change poses risks to food security by affecting various aspects of the agri-food value chain. Importantly, extreme droughts and heat waves reduce yields and nutritional value of crops, accelerate pests, diseases, and crop senescence, and disrupt supply chains and reduce shelf-life of products. Also, these impacts are higher when droughts and heat waves occur simultaneously (i.e., compound events). Climate adaptation strategies adopted by different actors in the agri-food value chain may alleviate negative impacts of climate change.

Methods

With increasingly available data on crop phenotyping, proximal and remote sensing, transportation, delivery, consumption, etc., data-driven models based on Machine Learning (ML) are gaining importance in guiding the decision-making in various aspects of the agri-food value chain. The project will utilize the use of hybrid approaches combining ML and process-based modelling. Moreover, the standardization of data schemata through ontologies and knowledge graphs would benefit the organization of data and provide new information for training ML-based models.

Results (expected)

Four work packages (WPs) are proposed that will focus on tailored solutions for different aspects. WP1 is an overarching WP that focuses on the standardization of data schemata and the joint development of ontologies and integrated knowledge graphs. WP2 focuses on the development of hybrid ML and process-based models for crop growth from time series data that involve essential genotype-by-environment (GxE) interactions. WP3 focuses on assessing the effectiveness of low-cost, nature-based management practices that are applicable by farmers in low-income countries for climate change adaptations. Lastly, WP4 focuses on better supply chain strategies for reducing food waste resulting from climate change.

In a close collaboration with various WUR partners

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

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

1. Intercomparison of multiple crop models to investigate their variability (uncertainty) of response to climate factors of temperature, CO2, and rainfall, as well as management inputs.
2. Testing multiple crop models against observed response data on temperature, CO2, 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 (expected)

- 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)

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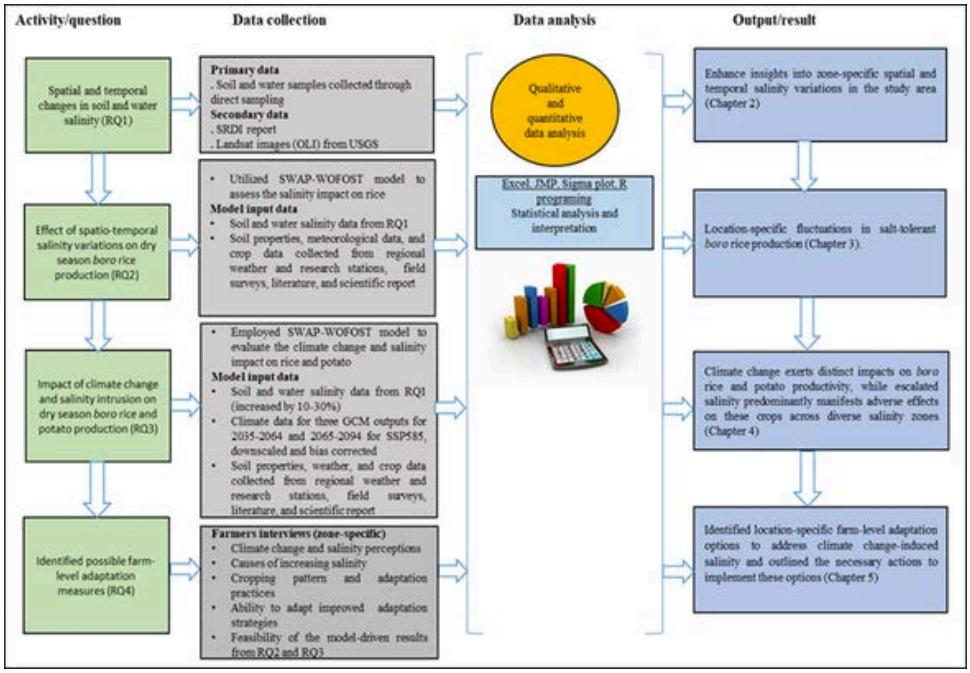
Salt intrusion and adaptation in the coastal zones of Bangladesh under changing climate

Research challenges

Bangladesh is blessed with many islands along the Bay of Bengal. Climate-induced changes such as rising sea levels and water balance may affect the agroecosystems of this area through saltwater intrusion. However, our understanding is limited to how these impacts will be unveiled in the future. This research aimed to determine the effects of climate change on agriculture in the south-central coastal districts using the SWAP-WOFOST model. Location-customized potential solutions were identified by synthesizing farmers' interviews, model-driven results, and existing literature. The findings of the PhD project will help in sustainable agricultural production in the coastal area of Bangladesh.

Methods



Results (expected)

This study provides comprehensive insights into zone-specific spatial and temporal salinity variation and includes information on the effects of such variations on salt-tolerant boro rice and potato yield in the south-central coast of Bangladesh. Moreover, in these regions, projected increasing salinity levels and climate change adversely affect major dry-season crops, even though elevated [CO2] levels partially or entirely compensate for the high temperature and salinity effects. Due to spatial disparities in salinity levels, crop yields, and cropping intensity vary across locations. Consequently, the implementation of zone-specific crop-level adaptation plans is imperative to enhance farm productivity. This research proposes potential location-specific farm-level adaptation plans. It will also contribute to advancing the objectives outlined in the national adaptation programs and policies.

Publications

Bhuyan, M.I., Supit, I., Mia, S., Mulder, M. and Ludwig, F., 2023. Effect of soil and water salinity on dry season boro rice production in the south-central coastal area of Bangladesh. Heliyon, 9(8).

Bhuyan, M.I., Mia, S., Supit, I. and Ludwig, F., 2023. Spatio-temporal variability in soil and water salinity in the south-central coast of Bangladesh. Catena, 222, p.106786.

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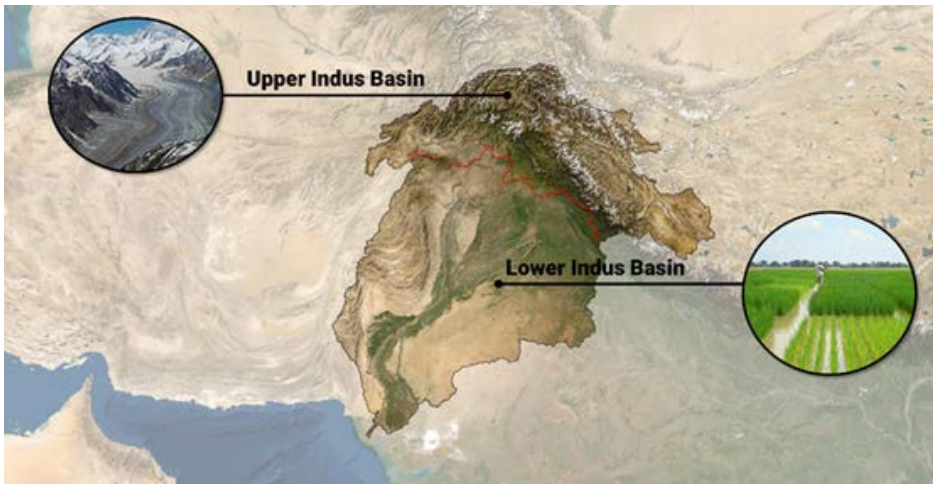
Evaluating the efficacy of field scale climate-smart innovations in agriculture & water sectors and assessment of their up-scaling potential for the Indus Basin.

Research challenges

Food production in the Indus basin mainly depends on irrigated agriculture; however, the changing climate poses uncertainty in future water availability. Adapting to Climate-smart agricultural practices (CSA) for irrigation of crops can provide a local mechanism for enhancing sustainable food production. However, to avoid mal-adaptation, CSA needs field scale evaluation, and subsequent upscaling potential assessment for Indus basin. This research project specifically focuses on sustainable upscaling potential assessment of CSA for irrigation in Indus river basin.

Methods

(1) Enlisting of adaptation options for agricultural water management in Indus river basin. (2) Field experimentation of selected adaption option and data collection (3) upscaling assessment of adaptation options using experimental data, field surveys, and geo spatial analysis tools. (4) synthesizing the results and providing a decision support roadmap for upscaling of assessed adaptation options in Indus river basin.



Results (expected)

The results will provide an overview of sustainable upscaling potential of selected adaptation options (Agricultural system change, Laser land leveling, Solar pumping, Rainwater harvesting) for Indus river basin. In conclusion the research results will highlight the potential areas for upscaling adaptation options within Indus river basin.

Publications

1.Spatial quantification of the potential of laser land leveling to reduce water demand for irrigated wheat production in the Indus river basin.
2.Exploring the potential of agricultural system change as an integrated adaptation strategy for water and food security in the Indus basin.
3.Transitioning from Diesel to Solar Photovoltaic Energy for Irrigation Tube Wells in the Lower Indus Basin, Pakistan, and its Impact on Groundwater Extraction
4. Rainwater harvesting potential for irrigation in current and future climates within Indus river basin

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3POLE2SEA

From the Third Pole to the Sea: impacts of melting glaciers and snowpacks on downstream water and food security

Research challenges

The high mountains of South Asia, often called 'the Third Pole', store large volumes of water in their glaciers and snowpacks. Twelve large river basins, fed with meltwater from these mountains, are home to almost 2 billion people. In their floodplains, a significant fraction of the global food is produced (34% and 23% of the global rice and wheat production respectively). This makes the 'Third Pole' a very important water reserve on which both water- and food security for a huge population depend.

The water supply from the Third Pole mountains faces many threats. Glaciers and snowpacks are melting at unprecedented rates, and large parts of these reservoirs are likely to disappear by the end of the 21st century. The dependence of downstream populations on mountain water resources is however increasing, mainly due to increasing water needs, continuing groundwater depletion and changes in (monsoon) precipitation.

There is still limited scientific understanding of the impacts of melting glaciers and snowpacks on food and water security of people living downstream. 3POLE2SEA aims to quantify the links between the water stored in the High Mountains of Asia and the water- and food security of the people living downstream, evaluate how those links will change in the future, and use this understanding to support adaptation design.

Methods

Development of new models and methods to quantify upstream-downstream links and associated risks for all river basins that are fed by glacier- and snowmelt from the Third Pole.

Results (expected)

We expect that the 12 river basins have very different upstream-downstream dependencies, resulting in different risks for water and food security, and therefore need different responses for effective adaptation.

The results will advance science and inform policy makers and water managers on how to make agriculture in one of the largest food producing areas in the world more resilient to changes in the mountains.

This project will start in June 2024. It is funded by an European Research Council Consolidator Grant.

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

Research challenges

The overall aim of SustaIndus is to develop sustainable pathways that support decision makers and practitioners to develop science-based policy and climate–smart solutions to provide food (SDG 2), water (SDG 6) and energy (SDG 7) to all people in the Indus now and in the future.

Methods

SustaIndus takes a multi-scale approach based on co-creation with regional partners and researchers.

Results (publications)

- 'A systematic framework for the assessment of sustainable hydropower potential in a river basin–the case of the upper Indus', https://doi.org/10.1016/j.scitotenv.2021.147142.
- 'From theoretical to sustainable potential for run-of-river hydropower development in the upper Indus basin', https://doi.org/10.1016/j.apenergy.2023.122372.
- 'Quantification of run-of-river hydropower potential in the Upper Indus basin under climate change', https://doi.org/10.3389/frwa.2023.1256249.
- 'South Asian agriculture increasingly dependent on meltwater and groundwater', https://doi.org/10.1038/s41558-022-01355-z.
- 'Future upstream water consumption and its impact on downstream water availability in the transboundary Indus Basin', https://doi.org/10.5194/hess-26-861-2022.
- 'Exploring the potential of agricultural system changes a an integrated adaptation strategy for water and food security in the Indus basin', https://doi.org/10.1007/s10668-023-03245-6.
- 'From narratives to numbers: Spatial downscaling and quantification of future water, food & energy security requirements in the Indus basin', https://doi.org/10.1016/j.futures.2021.102831.
- 'Spatial adaptation pathways to reconcile future water and food security in the Indus River basin', https://doi.org/10.1038/s43247-023-01070-3.

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Environmental limits to global groundwater use

Research challenges

While environmentally safe levels of surface water use are well documented, the same cannot be said for groundwater use. The purpose of our research, therefore, is to quantify the environmentally safe operating spaces of global groundwater abstractions to mitigate environmental harm while ensuring sufficient crop production is maintained.

Methods

We are quantifying environmentally critical groundwater discharge using a global-scale groundwater-surface water model. Ultimately, we seek to implement the environment as a water user into our newly coupled, dynamic model. In this manner, we can simulate water use and water allocation from natural, human-impacted, and environment-first model runs.

Results (expected)

We seek to quantify the environmental impacts of historic, current, and projected groundwater abstractions globally. Additionally, we strive to quantify the trade-offs between sustainable groundwater use and sufficient crop production.

Other information

This research is part of the larger Groundwater Sustainability and Crop Production project (GROW).

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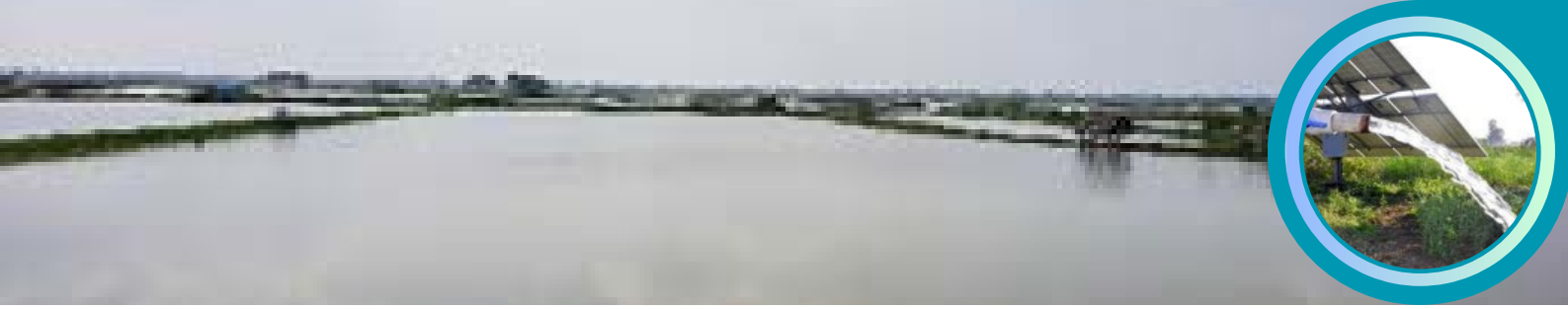


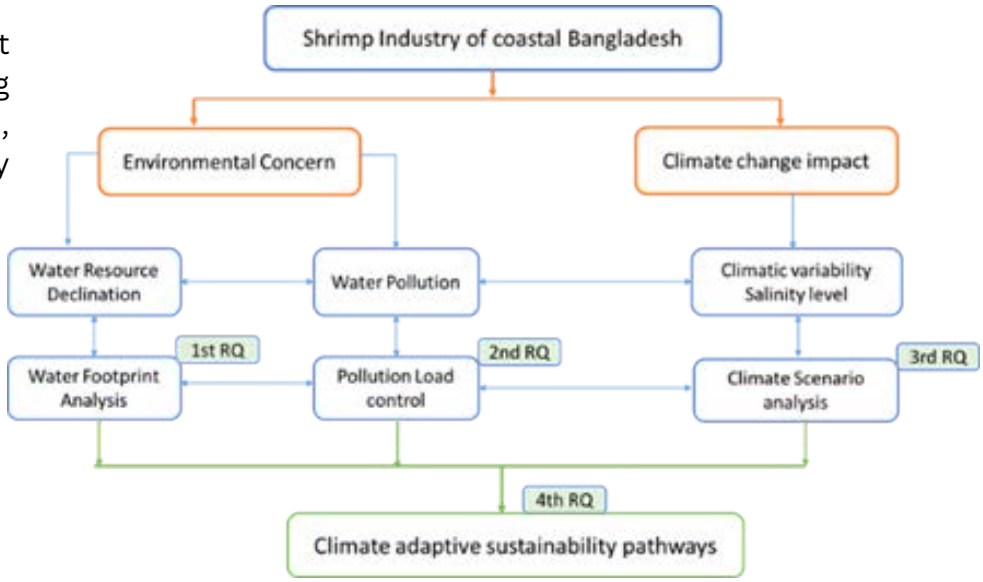
Environmental Sustainability of the Bangladeshi Shrimp Industry in the Context of Climate Change.

Research challenges

The shrimp industry is one of the major export sectors of Bangladesh and plays a significant role in the country's economy. The industry also supports around 6 million people's livelihoods, especially in the disaster-prone areas, where extreme poverty exists. However, the industry is currently struggling, especially in terms of water management. Moreover, climate change has made water management even more challenging. This study, therefore, intends to develop climate-resilient development pathways, considering water management issues and climate change, to make the shrimp industry more sustainable and climate-adaptive.

Methods

The study will use different research methods, focusing the participatory apporach, considering the study objective.



Results (expected)

It is expected that the study result will help the policy making process by improved understanding of future pressures and identify policy options to make the shrimp industry sustainable and climate adaptive. For instance, In this research, water footprint analysis of the shrimp industry will be performed. Moreover, This research project will introduce the scenario development and climate resilient development pathways, as a decision making tool in the private sector of Bangladesh.

This research project is funded under the Prime Minister Fellowship by Governance Innovation Unit of Bangladesh Government.

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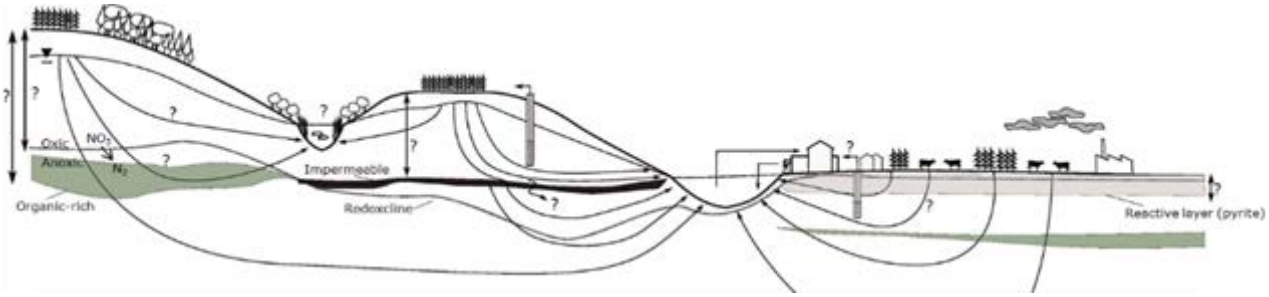
Nitrogen cycling in soil and groundwater, local phenomena on a global scale

Research challenges

This research aims to quantify the global role of groundwater in the N biogeochemical cycle and to study its evolution under changing land-use, climate change and evolving water cycle. Current conceptual modelling approaches lack explicit spatial variable representation of globally relevant hydrological and geochemical processes; importantly i) regional groundwater flow, ii) dynamic soil-crop cycling and iii) redox state control on denitrification. This project studies how nitrogen interactions in soil-groundwater can be described and upscaled into global models under socioeconomic and climate change scenarios.

Methods

To solve these research challenges, this project integrates an innovative global geohydrological model VIC-WUR/MODFLOW, into the conceptual large-scale nutrient balance model IMAGE-GNM. The project bases NO3 sinks on newly-generated global hydrogeochemical maps. This integrated approach quantifies past-current NO3 groundwater cycling and environmental effects by combining soil column, crop and groundwater numerical modelling. The developed model is furthermore used to study impacts on the nitrogen cycle by climate change with standardized SSP-RCP scenarios.



Results (expected)

With the upscaled model, NO3 storage, sinks and N2O production through denitrification in groundwater in the global biogeochemical cycle are quantified. The potential future changes in the role of groundwater in the N cycle are determined. This results in understanding of spatiotemporal control of agriculture on groundwater quality relative to human and ecosystem exposure, which makes spatially variably trade-offs between environmental and health effects with agricultural management and food production explicit.

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GROW: Sustainable Groundwater use and crop production

Research challenges

To assess globally, the contribution of groundwater to crops through both direct (irrigation/pumping) and indirect (capillary rise/root extraction) means. Identify the crop yield gap between a sustainable groundwater usage scenario and a business-as-usual scenario.

Methods

Through the use of a Global-scale groundwater-surface water-crop model (GSCM), which will consist of groundwater (MODFLOW), hydrological (VIC-WUR) and crop growth (WOFOST) components. Different model runs such as environment first or crop production focus scenarios will be designed for both historic and future timescales. Contributions can be extracted from the different water fluxes and global crop growth, production and yields will result from the crop modelling component.

Results (expected)

I will provide the first global-scale quantification of direct and indirect contribution of groundwater to crop production. This will contribute to improved insights in the role of groundwater in maintaining and enhancing global food security.
Furthermore, this PhD will show to what extent sufficient global crop production can be achieved while using groundwater sustainably.

This project is funded by the European Research Starting Grant

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5.7

Research projects

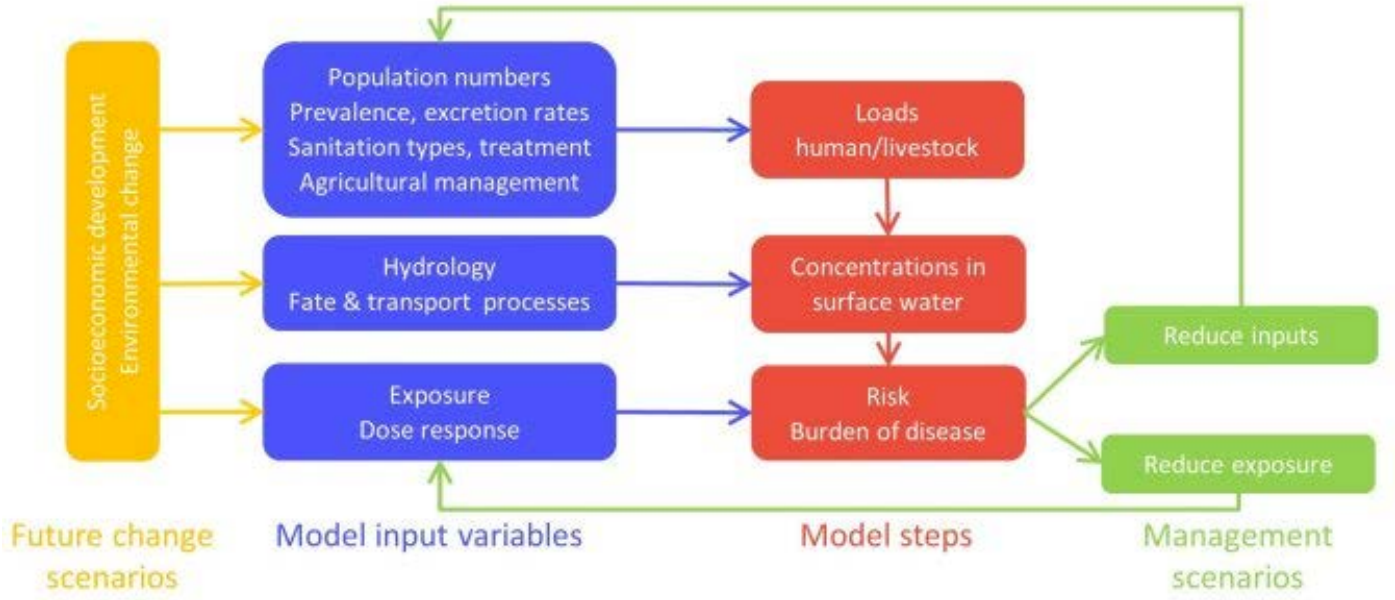
Water Quality (WQ)

WaterPath: a Future Scenario Toolkit for Waterborne Infectious Disease Modelling

Research challenges

Infectious waterborne diseases are globally still a major threat to human health. Climate change and other socio-economic changes may exacerbate this threat. In the WaterPath project we develop a toolkit with and for stakeholders to improve understanding in current and future health risks for the population and to help them design adaptation strategies. The aim of this project is to understand the impacts of socio-economic development and climate change on waterborne disease and spread of AMR to inform policy makers and help them design adaptation strategies.

Methods and Results (expected)



- The toolkit will provide knowledge for stakeholders on main patterns in pathogen concentrations and disease risk now and in the future (2030, 2050, 2100);
- This toolkit will provide open access to the Global Waterborne Pathogen (GloWPa) model and the data required for the model (present and future scenarios).

Project

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- https://research.wur.nl/en/persons/nynke-hofstra
- https://doi.org/10.1016/j.cosust.2018.10.002

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Multi-pollutant modeling of water quality

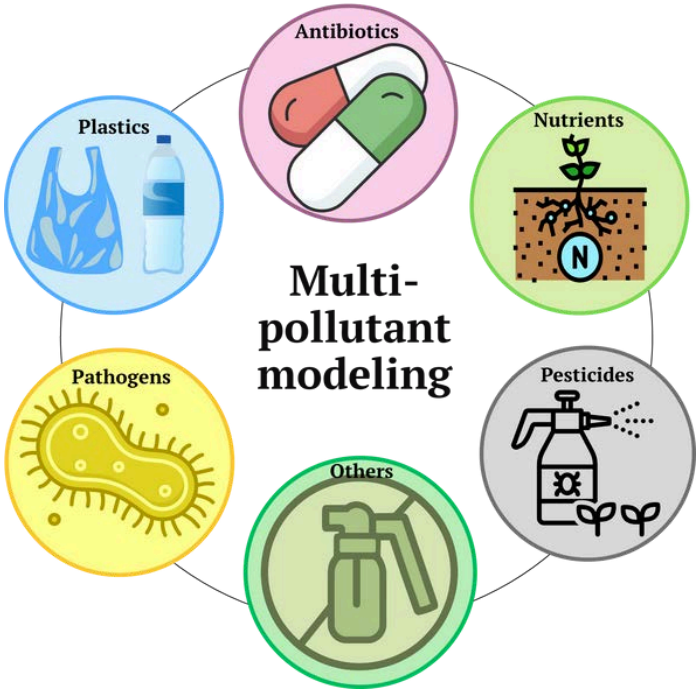
Research challenges

Multi-pollutant approaches are needed to assess water quality. Important reasons are that rivers, lakes and coastal waters contain more than one pollutant, they often result from common sources and have multiple impacts. In our subgroup, we contribute to a better understanding of multi-pollutant interactions in the cause-effect chain and identify pollution hotspots across the world and their causes. We also contribute to a better understanding of impacts on society and nature.

Methods

The Water Quality subgroup (co)develops new ways of multi-pollutant modelling of water quality in water systems worldwide, by using existing modeling approaches for individual pollutants. The combined models with their corresponding pollutants are:

- Global NEWS for nutrients;
- MARINA models for multiple pollutants;
- NUFER for nutrients;
- Antibiotics model;
- Macro- and micro-plastics models;
- Triclosan model;
- GloWPa for pathogens.



Results

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Food safety in a circular water and food system

Research challenges

The current risk assessment and management models (most commonly used are Water Safety Plan and QMRA in water management, HACCP in food production) are limited in their predictive capacity, because pathogen data is very limited in availability or is not shared cross-sectorally, and because a multitude of factors have an effect. To ensure food safety in a circular system, relevant risk factors must be weighed in an integrated manner to arrive at a maximally reliable risk assessment. The water boards will use the data & risk model developed in this project to draw up a Water Reuse Management Plan. The fruit and vegetable sector will use the model for risk-based and area-oriented monitoring of the presence of pathogens in surface/irrigation water.

Methods & expected results

The aim of the project is the development of an integrated risk analysis model that forms the basis for risk-based monitoring of human pathogens in surface water. New regulations force water and agricultural sectors to coordinate their risk management to guarantee a safe water and food system. In a circular water and food system, multiple, complex interacting factors influence the spread of pathogens via water and transfer to food.

This project also aims at cross-sectoral, risk-based monitoring to identify and manage new food safety hazards in a timely manner. This project creates a risk analysis model that takes into account as many risk factors as possible in the prediction of emerging food safety hazards and indicates where pathogen measurements can best be carried out.

Client(s): Ministry of Agriculture, Nature and Food Quality

Partners Wageningen University & Research

- WFSR
- WU-DES
- Deltares
- KWR
- GroenteFruit Huis (secretary)
- Food Compass Foundation
- net
- AQS Holding
- Orvion
- H2Okay
- Aa en Maas Water Board
- Brabantse Delta Water Board

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Global Water Quality Initiatives: Engagement of the WQ subgroup

Global Water Quality Initiatives

- **World Water Quality Allieance (WWQA):** a voluntary multi-stakeholder network that communicates water quality risks at various levels with the aim of identifying solutions for both ecosystems and humans, and supports the 2030 Agenda for Sustainable Development and beyond;
- **Inter-sectoral Impact Model Intercomparison Project (ISIMIP) and Process-based models for climate impact attributions across sectors (Proclias Cost Action):** International networks of modelers to develop water quality protocols and harmonize model datasets for joint cross-sectoral, multi-model climate impact studies at various scales for water quality assessments.

Engagement and development

WWQA

ISIMIP

Proclias

ISIMIP Inter-Sectoral Impact Model Intercomparison Project

WWQA World Water Quality Alliance

cost EUROPEAN COOPERATION IN SCIENCE & TECHNOLOGY

PROCLIAS

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VENI project: Clean Water for All

Research challenges

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 these complex interactions. For this, a multi-pollutant model with spatial optimisation is being developed, as depicted in the figure below.

Methods

The family of the MARINA models has been developed. MARINA is short for Models to Assess river Inputs of pollutaNts to seAs. In particular, the models quantify flows of multiple pollutants from land to waters by sources and from sub-basins for the past, present and future. The models are linked to cost-optimization approaches to identify the cheapest solutions.

Results (example)

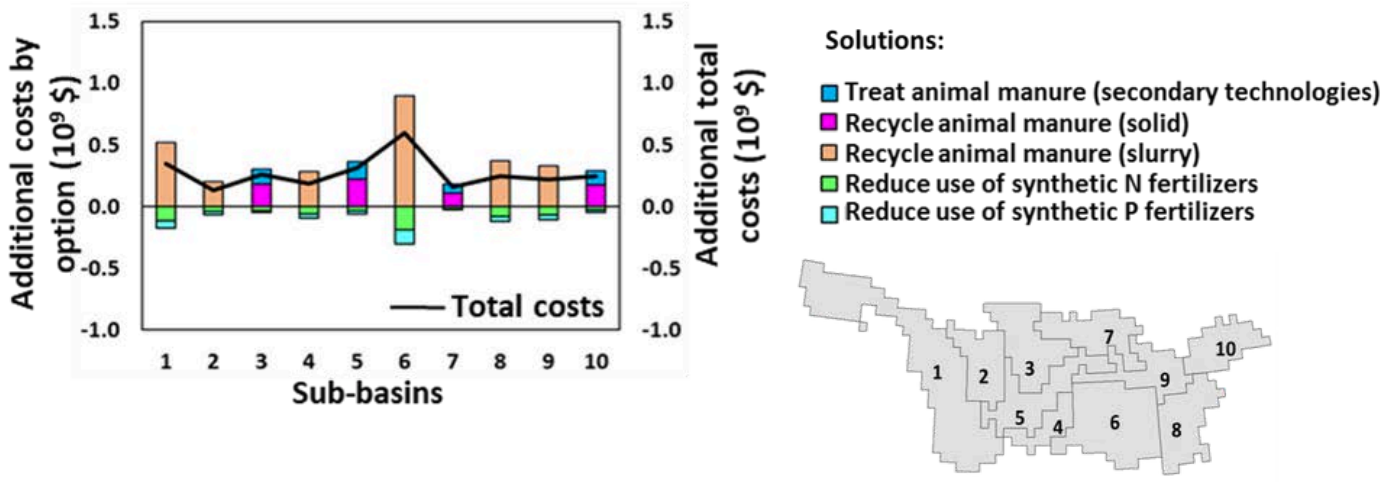

Figure: Research strategy to identify optimal sets of mitigation options to reduce future river export of multiple pollutants in selected hotspots by sub-basin, sector (option) and year (Strokal et al., 2021).

Links for more information:

- https://www.nature.com/articles/s42949-021-00026-w
- https://doi.org/10.1016/j.resconrec.2019.104635
- https://doi.org/10.1038/s41467-023-40501-9

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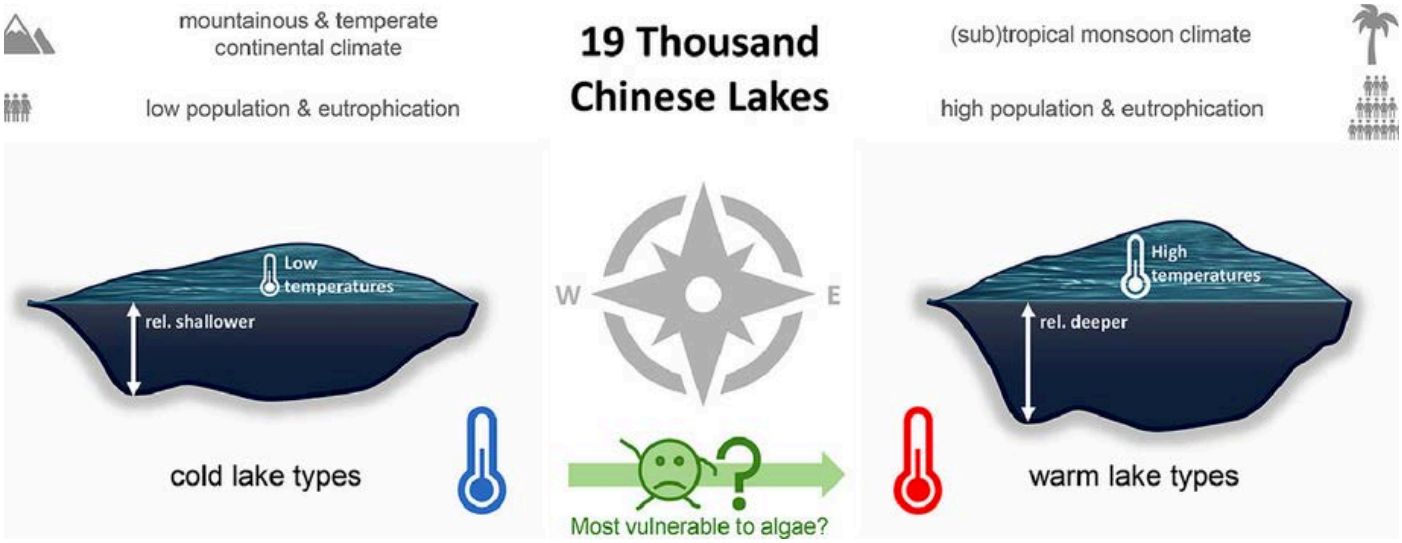
Lake Quality Modeling

Research challenges

Lakes, including ponds and reservoirs, are increasingly threatened by algal blooms. Yet, each lake is unique, leading to large inter-lake variation in lake vulnerability to algal blooms. We focus on representative lakes in the world. We also do analyses for Chinese lakes. In a NWO Veni project "Booming or blooming? The future of lakes in a changing world", we study the feedback loop between environmental pressure and ecosystem state to find optimal solutions to reduce algal blooms under four scenarios of mitigation and adaptation strategies. For example, we aim to assess the effects of unique lake characteristics on lake vulnerability to algal blooms. To this end, we built a novel and comprehensive database of lake morphometric, climate and sediment characteristics of 19,536 Chinese lakes.

Methods



Results (examples)

- Vulnerability to algal blooms differ among lakes, despite a similar nutrient load.
- We classified 19,536 lakes, including ponds and reservoirs, in China.
- Eastern lakes are deeper and warmer than western lakes.
- Eastern lakes seem typically most vulnerable to algal blooms with few exceptions.
- Most vulnerable lakes to algal blooms are located in areas with eutrophication.

More information:

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- https://www.nwo.nl/en/projects/viveni194002

NWO
Netherlands Organisation for Scientific Research

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MARINA: Models to River Inputs of pollutaNts to seAs

Research challenges

In short, MARINA is a Model to Assess River Inputs of pollutaNts to seAs.
We develop the MARINA family consisting of interdisciplinary, sub-basin scale models. Our MARINA models focus on multi-pollutant issues under global change. The models aim to quantify the levels of multiple pollutants in water, their sources, and trends in relation to interactions between climate and socio-economic systems at different scales in time (annual, seasonal) and space (past, present and future). The models are used to explore effective solutions under global change.

Methods & Results (examples)

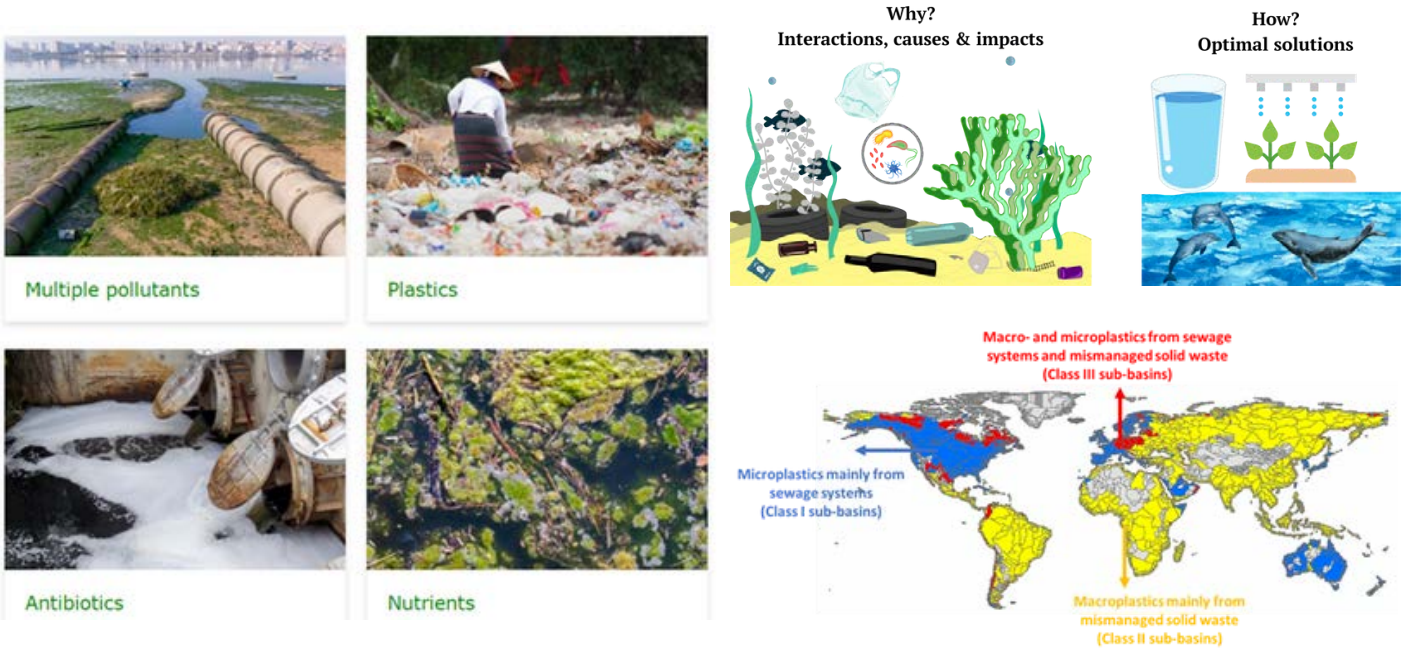
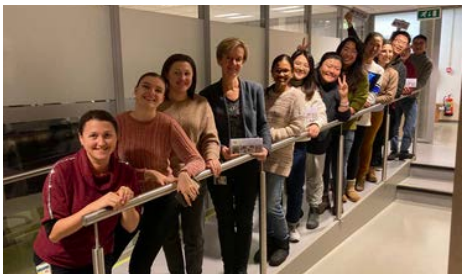


Figure: MARINA models for plastics, antibiotics, nutrients and other pollutants and a map (example) for plastic pollution in rivers and their main causes (https://doi.org/10.1038/s42949-021-00026-w, https://doi.org/10.1038/s41467-023-40501-9).

The MARINA team



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Hotspots and Causes of Multiple Pollutants in Waters

Research challenges

Agriculture and urbanization are important causes of multiple pollutants in water. With population growth and increasing food demand, more nutrients, plastics, pesticides, pathogens and antibiotics are expected to enter water systems (rivers, lakes, reservoirs, coastal waters) in the 21st century. As a result, water science has been shifting from single-pollutant to multi-pollutant perspectives for large-scale water quality assessments. We aim to better understand hotspots of multiple pollutants and their causes for the past, present and future under global change. For this, we develop and improve the water quality MARINA models.

Methods & Results (examples)

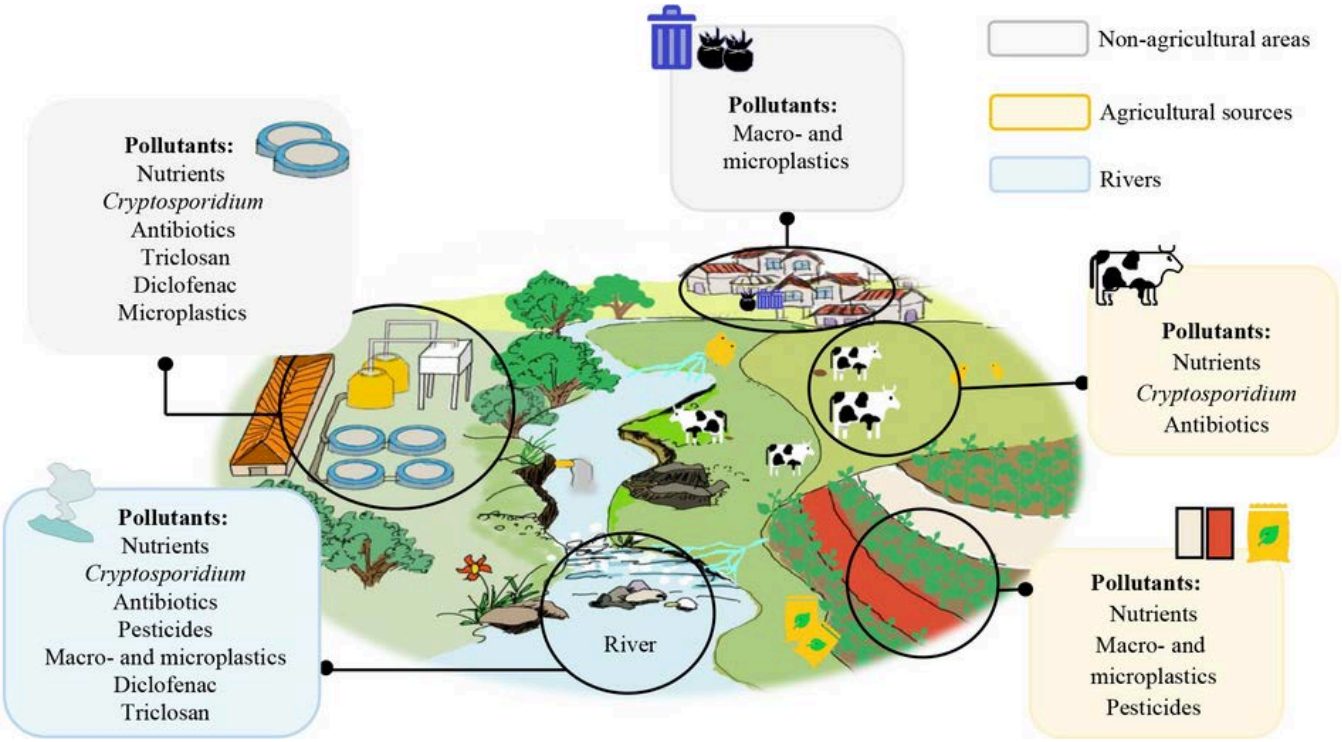
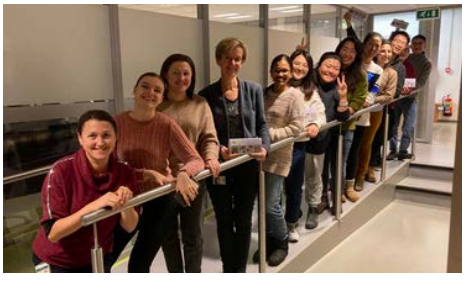


Figure: Summary of common sources of multiple pollutants in water systems (Wang et al., 2023: DOI: 10.15302/J-FASE-2023527).

The MARINA team



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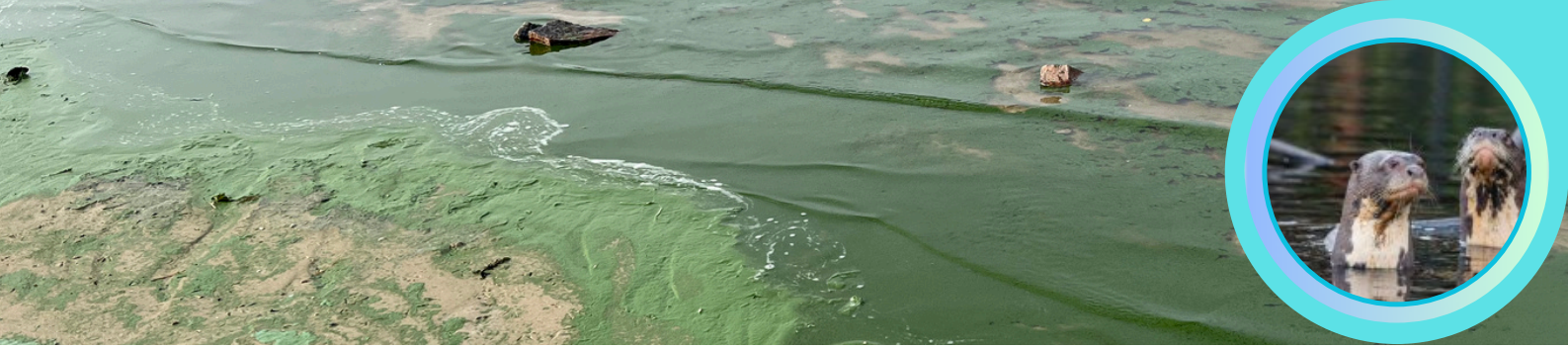

Multi-pollutant modeling of the Black Sea region

Research challenges

The population in the Black Sea region is expected to decline in the future. However, a better understanding of how river pollution is affected by declining trends in population and increasing trends in economic developments and urbanization is needed. This study aims to quantify future trends and fins solutions for reducing point-source emissions of nutrients, microplastics, Cryptosporidium, and triclosan to 107 rivers draining into the Black Sea.

Methods and Results (examples)

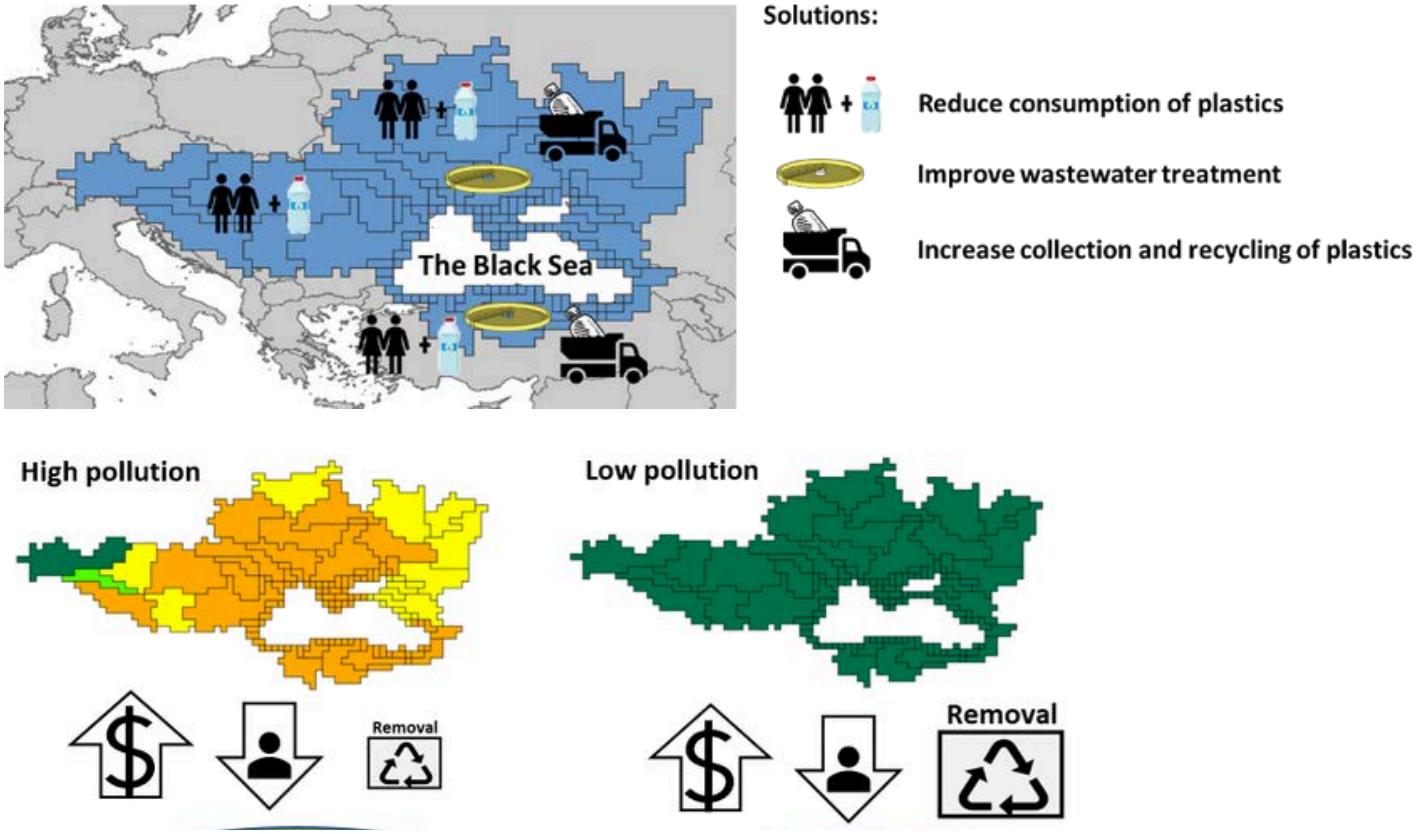

Figure: Identified solutions for reducing river and sea pollution from 107 sub-basins draining into the Black Sea (V.Strokal et al., 2022 and M.Strokal et al., 2022)

Links for more information:

- https://link.springer.com/article/10.1007/s13280-022-01780-6
- https://doi.org/10.1016/j.marpolbul.2022.113633
- CLIMAGRI4Ukraine project is acknoledged

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Global NEWS: Nutrient Export from WaterSheds

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

The Global NEWS (Global Nutrient Export from WaterSheds) model simulates the river export of nutrients from land to coastal seas by from point and diffuse sources. Point sources include sewage effluents from wastewater treatment plants, and diffuse sources include typically leaching/runoff of nutrients to rivers from fertilised and non-fertilised soils. Global NEWS takes into account the retention and losses of nutrients in the river network, including losses due to denitrification, water consumption, and damming.

Results (example)

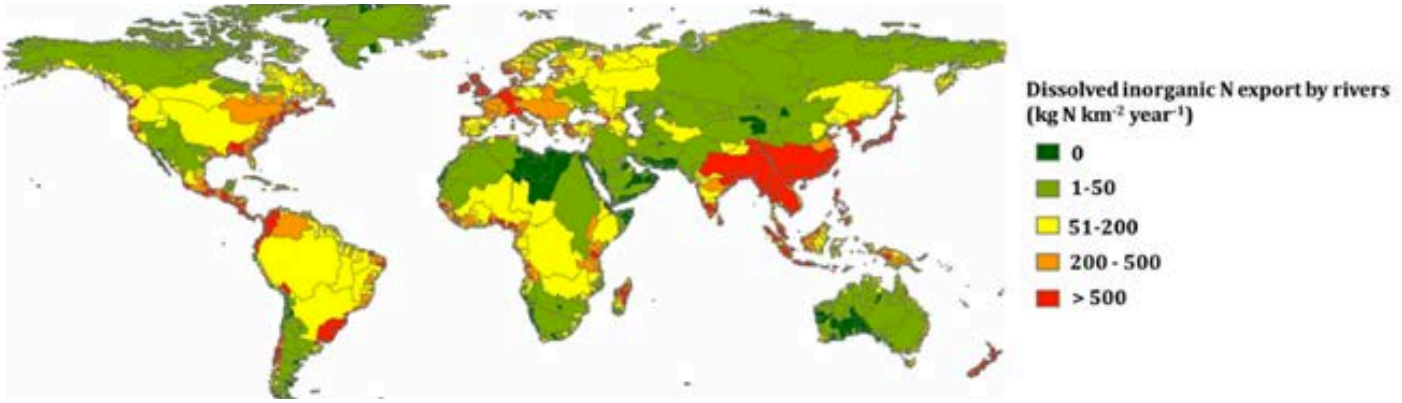

Figure: River export of nitrogen for 2050 (kg/km2/year) according to the Global Orchestration scenario of the Millennium Ecosystem Assessment.

Links for more information:

- https://doi.org/10.1016/j.envsoft.2010.01.007
- https://doi.org/10.1029/2009GB003587

Global *NEWS* model
Global Nutrient Export from WaterSheds

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Antibiotics in an Indonesian multifunctional reservoir: exploring its occurrence, sources, and impact on reservoir services

Research challenges

To contribute to safeguarding the future ecosystem services of Cirata as multifunctional reservoirs, this study aims to enhance understanding of antibiotics, including their environmental presence, potential sources, impacts on limiting ecosystem services, and mitigation options to minimize the effects of antibiotics on the services provided by the reservoir.

Methods

The type, level, and risk of antibiotics were assessed through direct sampling and measurement. Simultaneously, the relative sources of antibiotics was defined using MARINA models and a newly developed model. Utilizing the results from the first and second steps, the evaluation of how antibiotics will limit ecosystem services will take place. Subsequently, appropriate mitigation options to reduce the impact of antibiotics and nutrients will be selected based on their contributions to diminishing the antibiotics risk in the reservoir. By considering potential mitigation options alongside the current situation (level and risk) of antibiotics, the impact on each ecosystem service after the application of mitigation measures will be revealed.

Results (expected)

The type, spatial and seasonal distribution, and risk assessment (individual and joint mixture) of antibiotics to the aquatic organisms and their potential to develop antimicrobial resistance

- Class of antibiotics present: Fluoroquinolones, Sulphonamides, Lincosamides, Diaminopyrimidines, Amphenicol, Tetracyclines
- Antibiotics with higher detection frequency (%): Sulfamethoxazole, Sulfadiazine, Trimethoprim, Clindamycin
- As individual, most of fluoroquinolones present has critical risk to cyanobacteria and potential to develop anti-microbial resistance
- When presence in mixture, the antibiotics exhibit the critical effect to the aquatic organisms almost in all location sampling.

The developed models for determining the antibiotics source
The evaluation on how antibiotics and nutrients will limit the ecosystem services
The potential mitigation options to promote the reservoir's sustainability

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lembaga pengelola dana pendidikan

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Another season, another cocktail: Modelling seasonal effects of lake retention on river export of pollutants

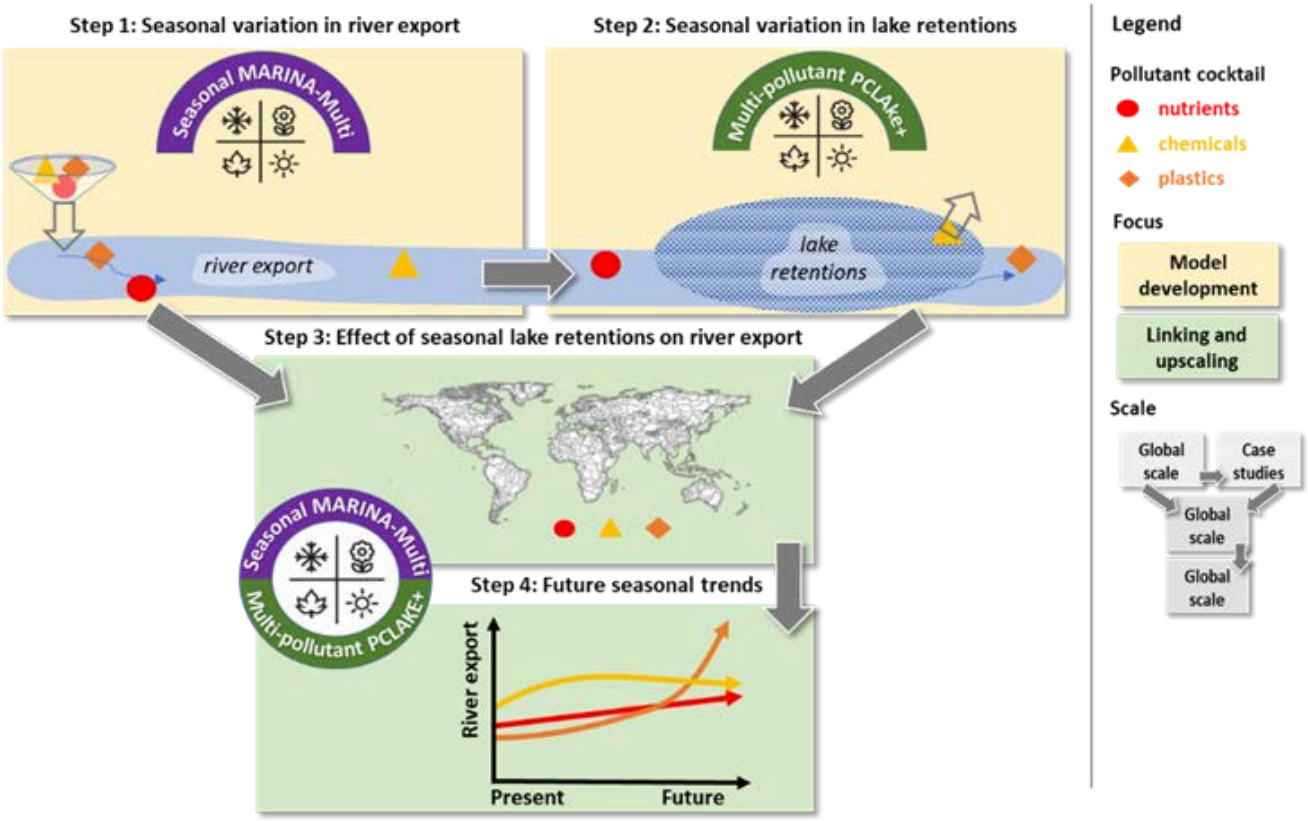
Research challenges

Water pollution is a global challenge. Human activities on land emit pollutants such as nutrients, chemicals, and plastics. This mixture of pollutants forms a cocktail with many interactions and are exported by rivers. Yet, current knowledge is still poor in understanding the seasonal effects of multi-pollutant issues. Hence, challenging formulations of effective management strategies to ensure clean water across seasons. My PhD research aims to better understand how seasonality in lake retentions affects river export of multiple pollutants worldwide today and in the future.

Results (expected)

My research will result in an integrated model system that provides novel insights into seasonal multi-pollutant flows in rivers and lakes. This will advance our knowledge on the seasonal effects of lake retentions on river exports of pollutants. This will aid policymakers in identifying management strategies to reduce seasonal water pollution for ecosystems and society.

Methods



More information:

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prof. dr. Carolien Kroeze
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Spatial and temporal distribution of algae patterns in Taihu Lake and its impact factors based on big data and deep learning

Research challenges

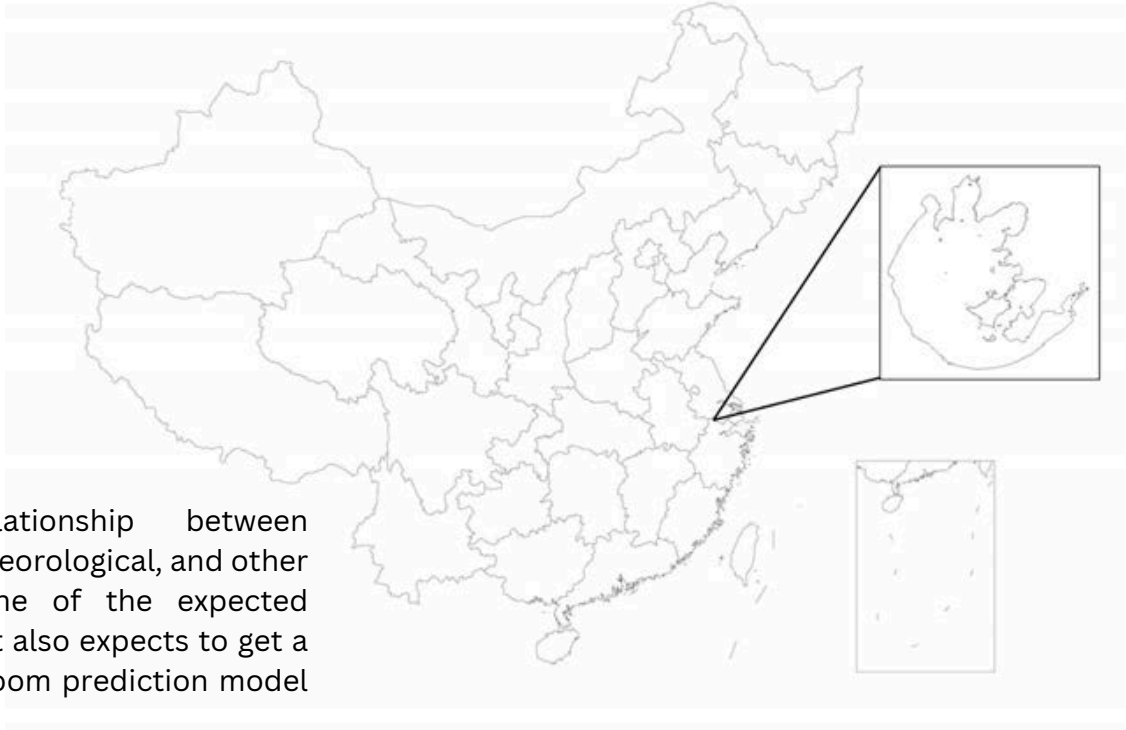
Lakes are of vital importance to the Chinese population for example by providing a source of drinking water. Taihu Lake is iconic in this perspective by being an important water source for its surrounding cities. The lake experiences frequent reoccurrence of algal blooms since 2007, threatening the drinking water safety of tens of millions of people. Therefore, it is important generate an algal bloom prediction model with high accuracy to prevent dire repercussions on human health.

Methods

This project will use remote sensing data to generate a high-spatial and high-temporal resolution dataset. This dataset will be used to study algal blooming patterns. Impact factors will be identified using casual analysis based on the patterns. With this knowledge, the deep learning techniques will be used to generate an algal bloom prediction model.

Results (expected)

This project expects to get a dataset of Taihu Lake algal bloom patterns with high spatial and temporal resolution.



The casual relationship between environmantal, meteorological, and other factors is also one of the expected results. This project also expects to get a short-term algal bloom prediction model for Taihu Lake.

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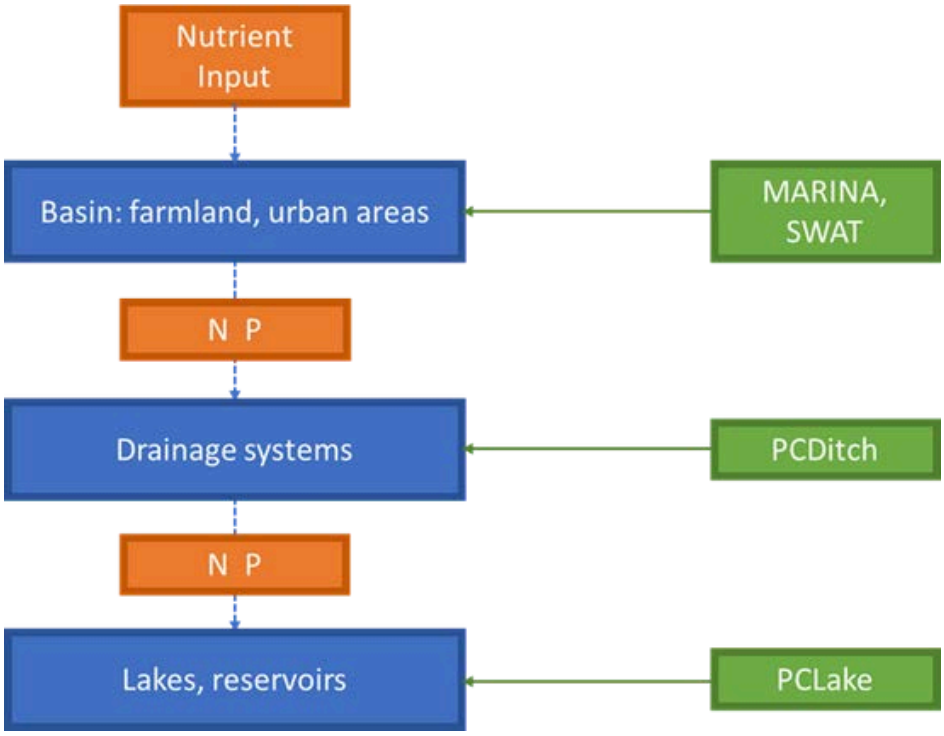
Modelling sources and fate of nutrients in water systems for effective water quality management

Research challenges

- Model Integration;
- Parameterization;
- Data Availability
- Quality;
- Scale Mismatches;
- Uncertainty Analysis.

Methods

My research utilizes the SWAT model to study the migration and transformation of nutrients on land, and the PCLake model to simulate the flow of nutrients along food chains and food webs in lakes, as well as the storage and release of nutrients at various interfaces.



Additionally, I employ the SSP-RCP framework to predict the impacts of future human activities and climate change on lake water quality, and to explore potential management strategies for improving lake water quality.

Results (expected)

For lakes like Erhai in the early stages of eutrophication, internal nutrient source contributions outweigh external sources. Due to the close correlation between internal and external sources, the focus of lake water quality management can be on reducing external nutrient inputs to decrease internal nutrient release and lower lake nutrient levels. With future global warming, the critical nutrient load of lakes will also increase, posing greater challenges to lake water quality management. Policy makers need to make specical policies to improve water quality

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- https://doi.org/10.1016/j.jenvman.2022.116712

Institute of Agricultural Resources and Regional Planning (IARRP) of the Chinese Academy of Agricultural Sciences (CAAS) within the Joint PhD Program in Agriculture and Life Sciences between the Graduate School of Chinese Academy of Agricultural Sciences (GSCAAS) and the University of Wageningen, the Netherlands (Approval MOE11NL1A20151701N).

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Solutions for Air and WaterPollution for Agriculture Green Development in China

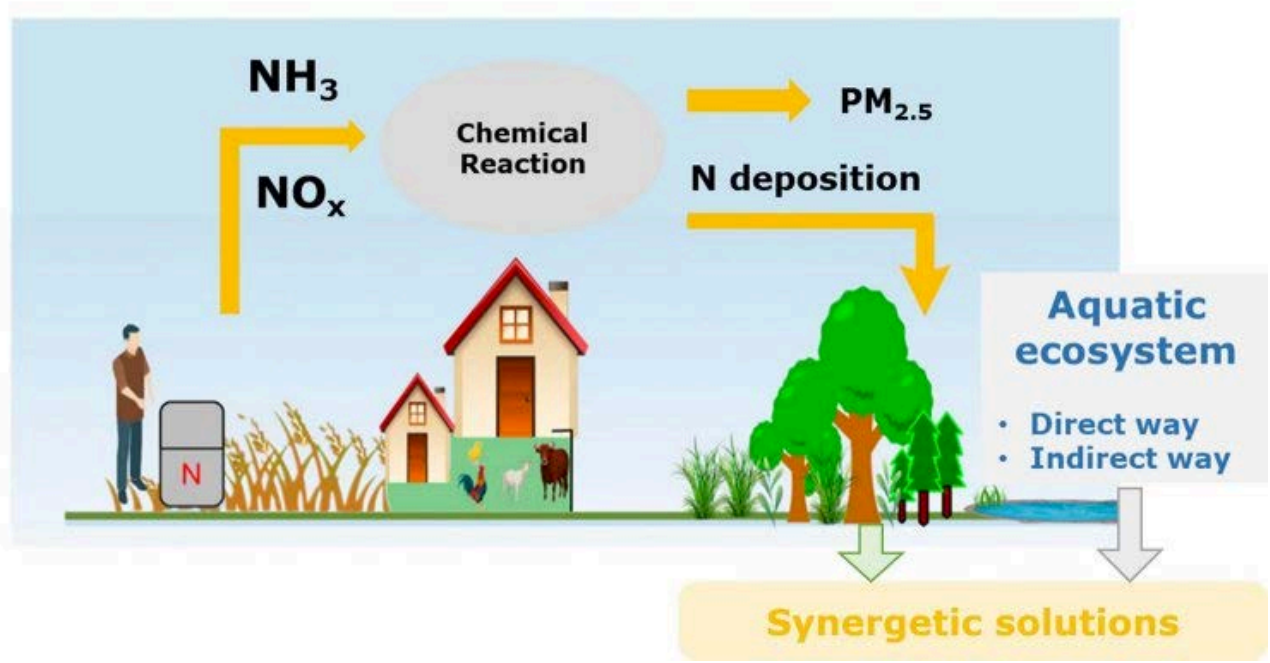
Research challenges

Human activities leads to excessive atmospheric nitrogen (N) deposition on land and rivers. Part of the deposited N on land is transported to rivers, contributing to water pollution by N. It is meaningful to explore synergetic measures to reduce pollution of water and atmosphere from sources simultaneously. This project aims to better understand the impact of nitrogen deposition on water quality and explore synergetic options of air and water pollution to reduce this impact in the future.

Methods

- Goddard Earth Observing System with Chemistry(GEOS-chem) ;
- Model to Assess River Inputs of PollutaNts to seA (MARINA);
- Scenario analysis.

Results (expected)



- Evaluate the effects of emissions controls on atmospheric nitrogen inputs to Chinese river basins;
- Formulate comprehensive and synergistic options and technologies within the AGD framework to mitigate future air and water pollution in China.

Supervisor(s):

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Probabilistic modeling of microplastic transport and risks across scales (AEW and ESC groups)

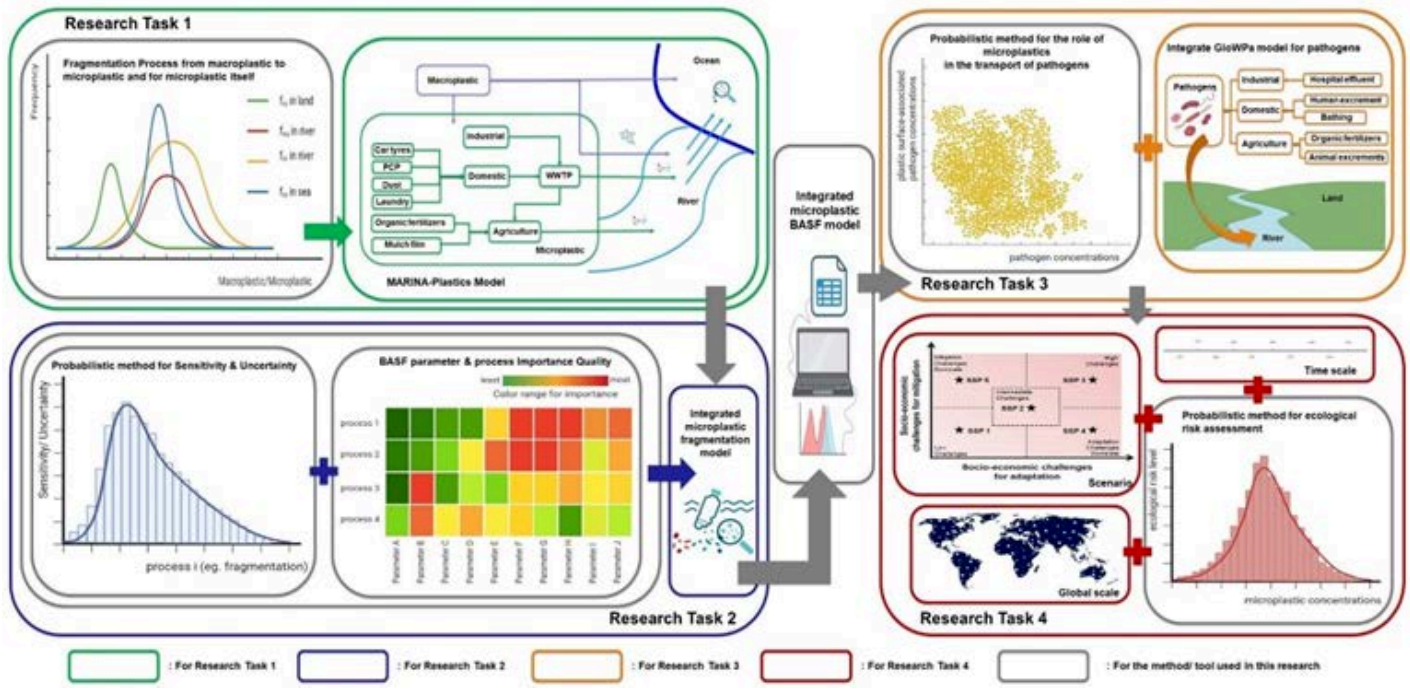
Research challenges

As microplastics constitute a global problem and are subject to multiple processes, that are inherently uncertain, it is necessary to better understand the role of uncertainty and variability associated with microplastic transport and risk assessment on a global scale. This will help to understand if microplastic can be seen as a planetary boundary threat.

Results (expected)

- A new fragmentation framework for formation of microplastic from plastics and microplastics' fragmentation and develop a global stochastic microplastic fragmentation model;
- Uncertainty and sensitivity in modelled concentrations;
- The relationship between pathogens and microplastics;
- Environmental risks will be characterized.

Methods



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Dr. Maryna Strokal
Dr. Merel Kooi

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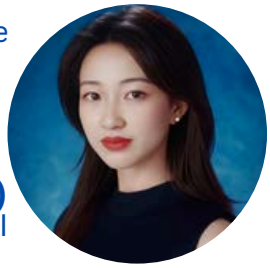

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Multi-pollutant assessment and solutions for clean water in Three Gorges Reservoir area in China

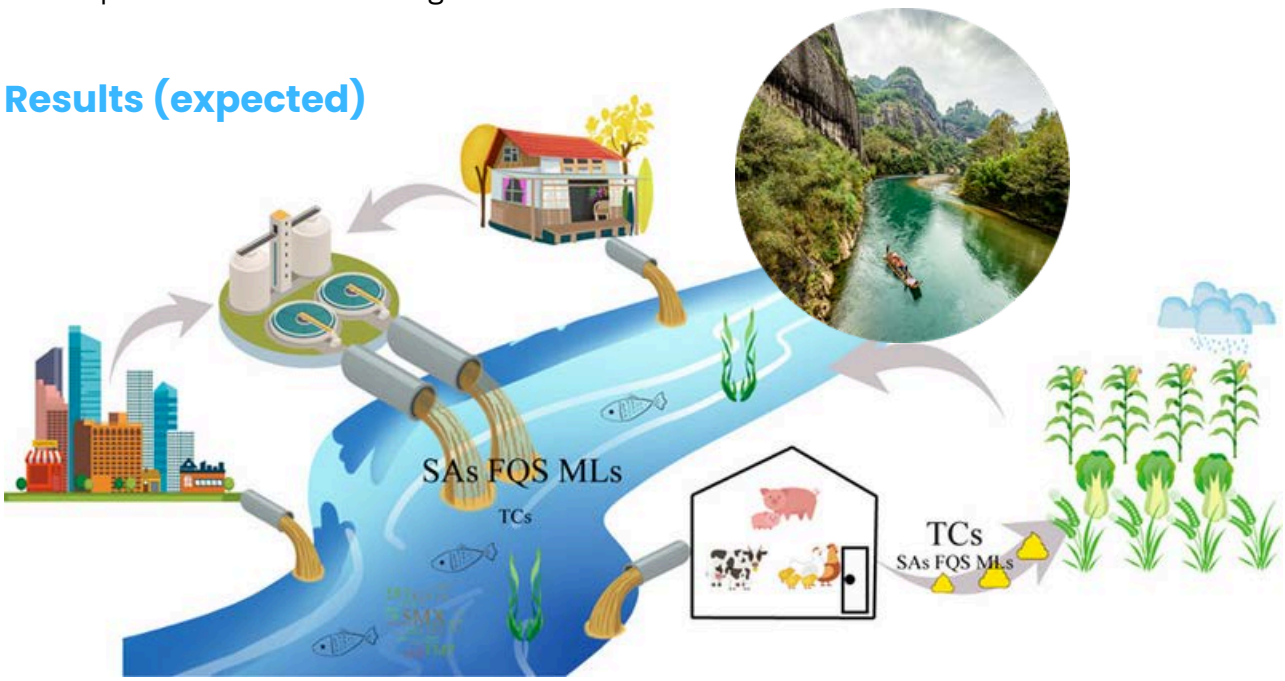
Research challenges

This project will focus on 1) quantifying the flux of multi-pollutants from the typical cropping systems to the surface water in the Three Gorges Reservoir area, 2) establishing antibiotics and fungicides model for simulating multi-pollutants hotspots and concentrations in the TGRA 3) evaluating the potentials of manure replacement technologies and multi-pollutants control technologies; and designing the agriculture-livestock scenarios with low environmental costs in the Three gorges reservoir area. This project will provide theoretical support to the agricultural green development in the Three Gorges reservoir area.

Methods

- Meta-analysis,
- Back-casting method,
- Scenario-analysis,
- Antibiotics and fungicide model

Results (expected)



- Identified the relationship between the antibiotic pollution status and the human activity (see Li et al., 2023: https://doi.org/10.1021/acs.estlett.3c00536);
- Antibiotic and fungicide models will be developed and environmental impacts will be evaluated to support agricultural green development for the TGRA.

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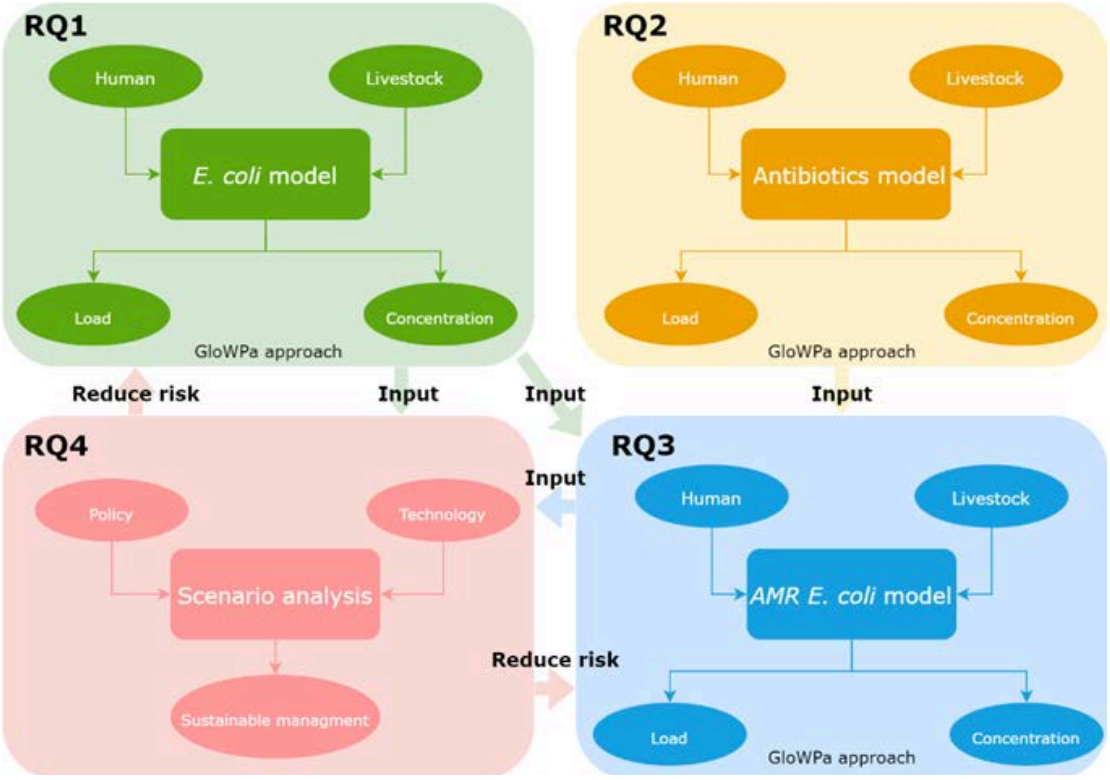
Modelling of antibiotics and antimicrobial resistant bacteria in rivers in China

Research challenges

Antibiotics in the environment pose a potential risk to ecosystems and human health. Under the selection pressure of antibiotics, microorganisms can develop antimicrobial resistance (AMR), which counteract the effectiveness of antibiotics.

In China, there is a lack of data on concentrations of antibiotics, E. coli and AMR E. coli in many regions. There is a need for an integrated modeling approach to identify the relative importance of pollution sources, assess the associated risks and support the decision-making process on environmental management.

Methods



- GloWPa (Global Waterborne Pathogen) model;
- Scenario analysis
- Risk assessment.

Results (expected)

- Hotspots and the relative importance of various sources of antibiotics, E. coli, AMR E. coli in rivers in China will be identified;
- Sustainable management solutions of antibiotics and AMR E. coli will be explored.

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AGD program:

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Innovative forecasting approaches to assess future trends in pollutant flows from land to water systems for advancing sectoral water quality service

Research challenges

Water pollutant impacts nature and society. In the future, this may continue because of socio-economic developments and climate change. Nutrients, chemicals, and plastics are examples of contaminants. They have common sources such as agriculture and cities. My research aims to assess trends in the flows of multiple pollutants from land to water systems, and to explore effective measures to achieve clean water for multiple sectors in the future at the sub-basin scale worldwide.

Methods

Results (examples)

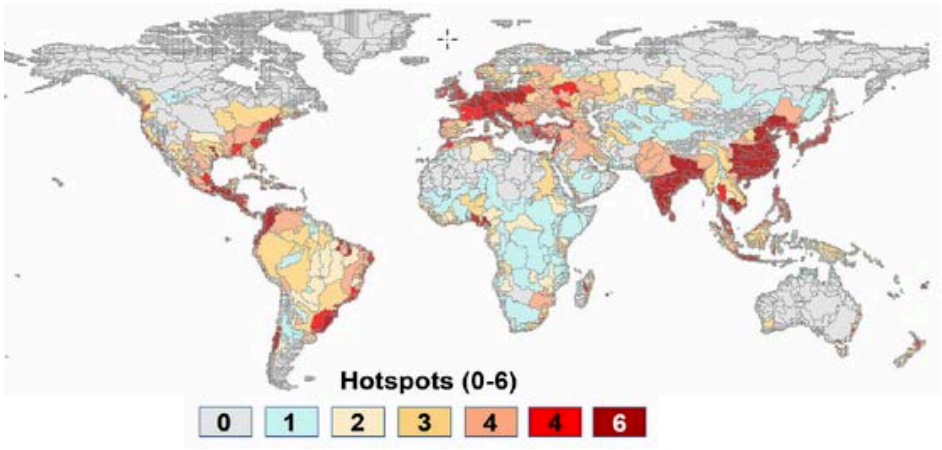

Figure: The relative shares of sub-basins with the highest river exports of pollutants (from 0 to 6 pollutants)

Almost 45% of global areas are multi-pollutant hotspots hosting 89% of the global population.

(see Micella et al., 2024: https://doi.org/10.1016/j.marpolbul.2023.115902)

Supervisor(s):

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Prof. Dr. Carolien Kroeze
Dr. Ting Tang
prof. Yoshihide Wadal

More information:

- https://doi.org/10.5194/egusphere-egu23-2336; https://doi.org/10.1016/j.marpolbul.2023.115902.
- https://inventwater.eu/

This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Sklodowska-Curie grant agreement 956623. MSCA-ITN-ETN – European Training Network. inventWater (Inventive forecasting tools for adapting water quality management to a new climate) Project.

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Modeling of rotavirus emissions-concentrations-risks and burden of diarrheal disease for water sources in Uganda

Research challenges

Rotavirus is a globally important waterborne pathogen causing high infant mortality and morbidity from gastroenteritis. In Uganda, 7% of all deaths in children below 5-years are due to rotavirus infections. The country's low coverage of improved sanitation, improper fecal sludge disposal and wastewater treatment exacerbate rotavirus transmission via the fecal-oral route.

Methods

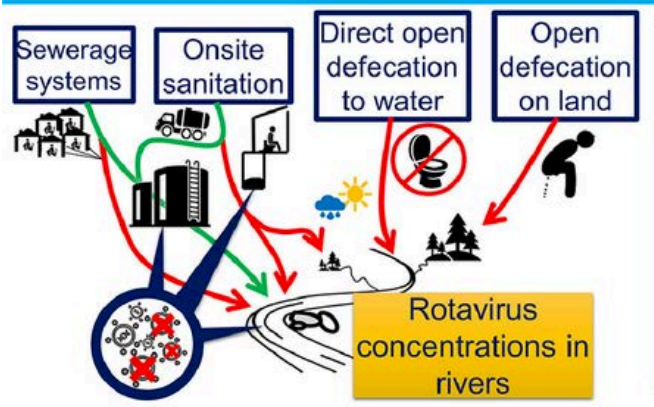
- Global Water Pathogens (GloWPa) model,
- Scenario-analysis
- Water-K2P Project stakeholders

This project aims to

- develop a modelling framework to estimate rotavirus emissions (loads) and concentrations reaching surface water from sanitation systems in Uganda;
- develop a framework to estimate the relative risk and diarrheal disease burden for the different rotavirus exposure scenarios on case-by-case basis;
- study the impacts of socio-economic and climate change on modelled rotavirus output and the estimated disease burden.

Results (examples)

Modelled pathogen flows



Scenario analysis

Influence on concentrations for the Sustainable (1) and Middle-road (2) scenarios:

Scenario	1	2
Climate change	→	→
Population	↑	↑
Urbanization	↑	↑
Sanitation usage	↓	↑
Treatment	↓	→

- Key sources are open defecation, limited treatment of wastewater and faecal sludge.
- A hotspot is identified as a densely populated area with poor sanitation coverage.
- (see Okaali et al., 2021: https://doi.org/10.1016/j.watres.2021.117615)

Supervisor(s):

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- https://doi.org/10.1016/j.watres.2021.117615
- 10.1177/23998083221120824
- 10.2134/jeq2017.12.0497
- This study is supported by the Bill and Melinda Gates Foundation and contributed to the Global Water Pathogens Project, which piloted the Knowledge to Practice (Water K2P) Uganda chapter, themed: Utilizing the Global Water Pathogen Project (GWPP) to meet the SDGs.

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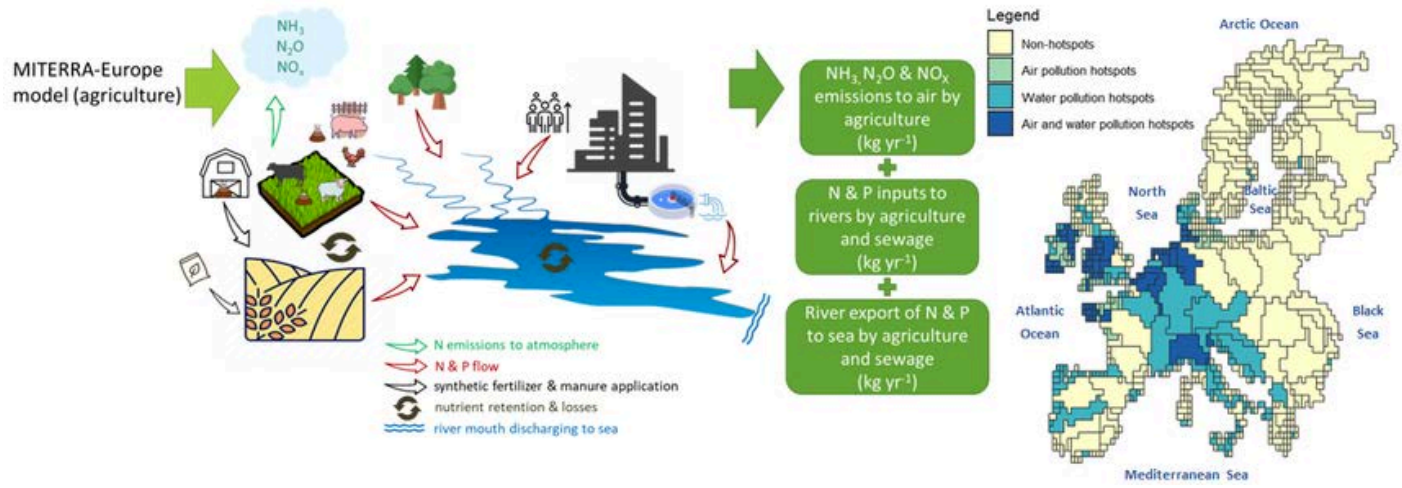
Modelling the effects of bio-based fertilizers use on air and surface water pollution at basin and European scales

Research challenges

The EU Green Deal's "Farm-to-Fork Strategy" has two significant ambitions on reducing fertilizer use by 20% and nutrient losses by 50% in 2030. The European Commission proposed to find solutions to convert organic wastes into high quality fertilizers (bio-based), reducing waste production and contributing to circular economy. However, the production process and application might also have negative effects on air and water quality. This study aims to assess the effects of bio-based fertilizer use on air and water pollution at basin (catchment) and European scales, and to explore mitigation options.

Results & methods

- A new MARINA-Nutrients model is developed to assess air and water pollution in Europe;
- Integrated assessment of bio-based fertilizers replacement on future nutrient losses in Europe;
- Identification of synergistic mitigation options to diminish the environmental impacts of bio-based fertilizers.



Nutrient export to European seas is expected to increase by 13-28% by 2050 under global change.

Agriculture is responsible for 55% of N and sewage for 67% of P in rivers.

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More information:

- https://journal.hep.com.cn/fase/EN/10.15302/J-FASE-2023526
- https://plen.ku.dk/english/research/plant_soil/sf/research-projects/ferticycle/

This study has been developed within the scope of the FertiCycle project which is an Innovative Training Network (ITN), and has received funding from the European Union Horizon 2020 Marie Sklodowska-Curie Action under Grant Agreement No 860127.

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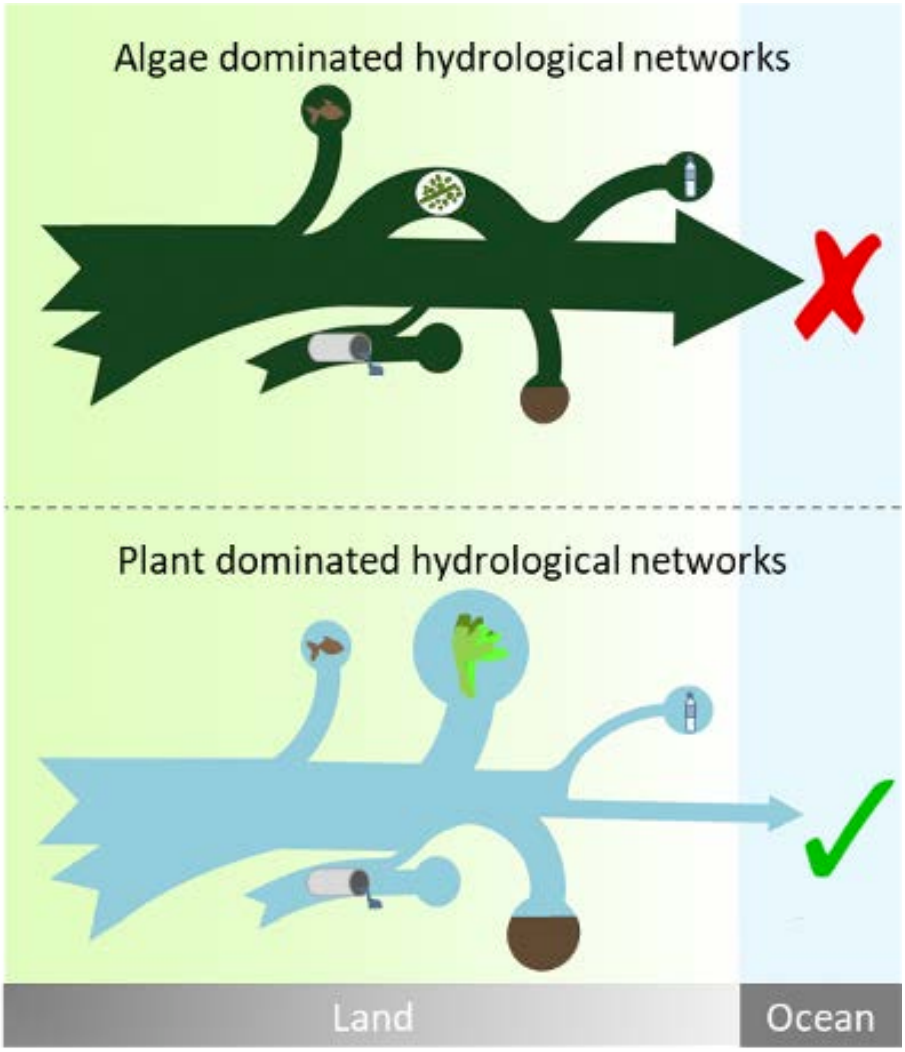
Smart Nutrient Retention Networks for good water quality and sustainable nutrient use

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.
The objectives of this PhD research are to (1) study the positive feedback loop between nutrient loading, water quality and nutrient retention in hydrological networks; and (2) to develop smart nutrient retention networks (SNRNs) to improve water quality and recycle valuable nutrients. Smart Nutrient Retention Networks combine management strategies to optimize nutrient retention to reach network wide improved water quality.

Methods



Results

The figure on the left displays 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.

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- https://research.wur.nl/en/persons/dianneke-van-wijk
- 10.1016/j.watres.2023.119950
- 10.1080/20442041.2020.1870852
- https://www.naturetoday.com/intl/nl/nature-reports/message/?msg=29199

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Agricultural Green Development Pathways for food and water in China

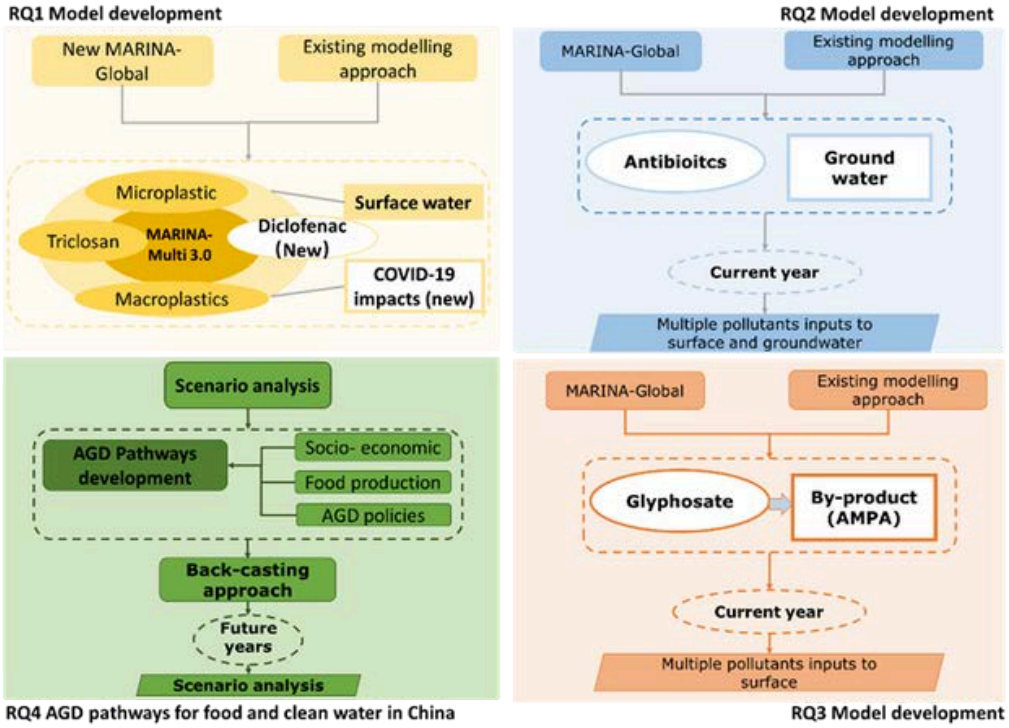
Research challenges

The main research objective of this research is to explore future Agricultural Green Development (AGD) pathways for clean water in China in the 21st century. For this, a multi-pollutant model is developed to quantify inputs of pollutants to surface and ground water today and in the future. Agricultural Green Development (AGD) pathways are developed and integrate optimistic solutions to increase the availability of clean water under sustainable agriculture in China.

Results

- Better understading of anthropogenic impacts (personal care products, painkillers and mismanaged plastic waste) on surface water quality;
- Better understanding of agricultural activities (antibiotic) on groundwater quality;
- Spatial explicit analysis of pesticides from agricultural activities in surface waters;
- New Agricultural Green Development (AGD) pathways for food production and water in China.

Methods



Research strategy to answer my four research questions (RQ)

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AGD program:

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- https://doi.org/10.1016/j.crsus.2023.100001

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

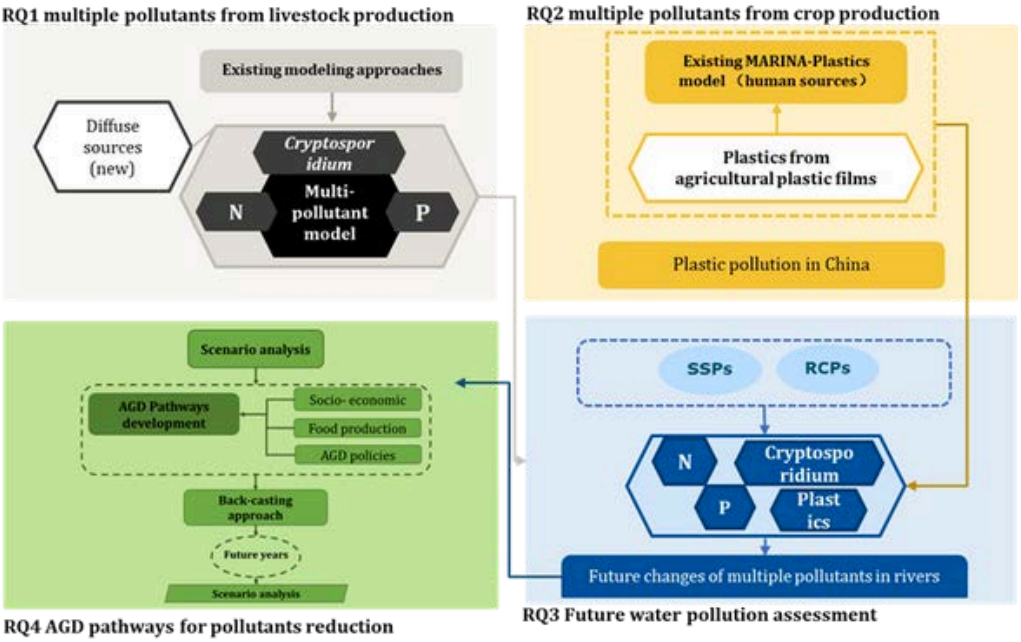
Research challenges

Intensified food production and human activities often add multiple pollutants (e.g., nutrients, pathogens and plastics) to aquatic systems. Agricultural Green Development (AGD) 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 (AGD) in China, in terms of sustainable food production and multiple pollutants in water systems at different scales.

Results

- New MARINA-Multi (Global 2.0) model to assess inputs of nutrients and *Cryptosporidium* to surface waters by source and sub-basin at the global scale;
- Identified the hotspots and their sources for plastic pollution in Chinese sub-basins;
- Assessed future trends in multi-pollutant problems for China;
- New Agricultural Green Development (AGD) pathways for sustainable food production and clean water in China.

Methods



Research strategy to answer my four research questions (RQ)

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More information:

- https://doi.org/10.1016/j.watres.2021.117906
- https://doi.org/10.1021/acs.est.3c03374

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Exploring AGD solutions and their effectiveness by developing a new integrated approach for decision support

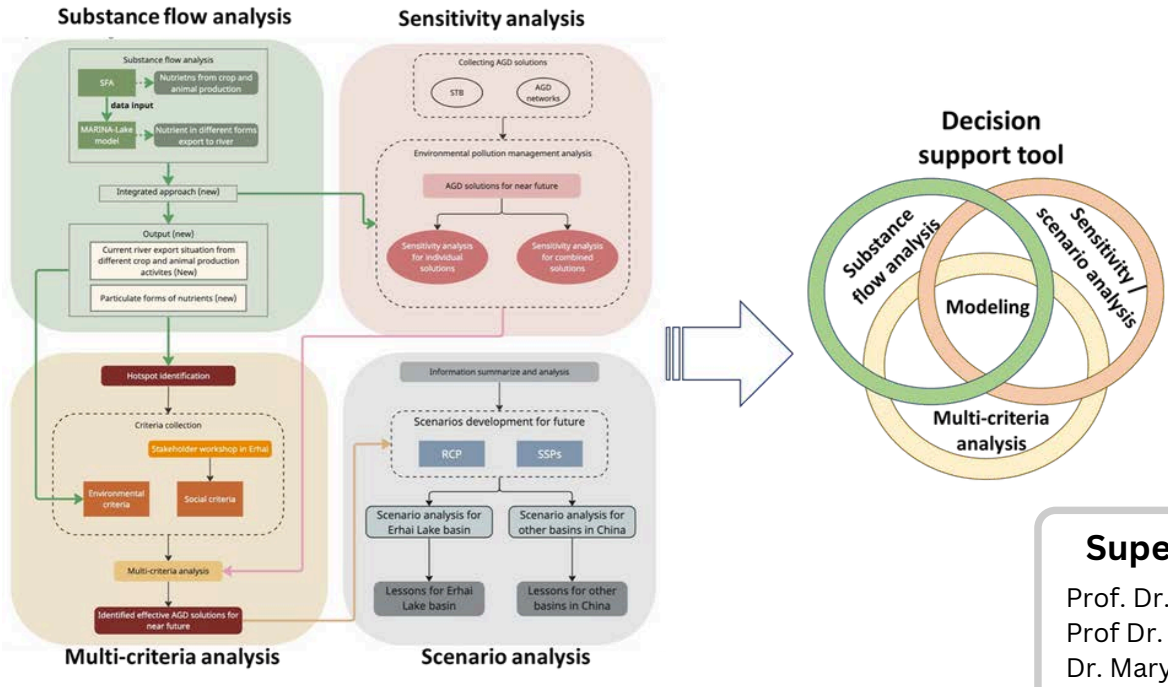
Research challenges

1. Agricultural Green Development (AGD) is promising, calling for synergetic solutions;
2. Lack of an integrated approach to estimate nutrient pollutions in water and air in Erhai Basin.
3. Trade-offs and co-benefits of current AGD solutions between food production and pollution control for air and water is still unclear.
4. The main objective is to develop explore AGD solutions to support decisions for pollution control in the Rhai basin.

Results (expected)

- MARINA-Lake model based on the Substance Flow Analysis (SFA) to estimate the nutrient pollutions.
- Sensitive Analysis to assess the co-benefits and trade-offs of AGD solutions.
- Multi-Criteria Analysis will be used to develop a decision-support tool to evaluate the effectiveness of the collected AGD solutions.
- Scenario Analysis will be used to integrate insights form previous steps to identify the pathway of decision-support tool development and upscale for other basins and for future.

Methods



Supervisor(s):

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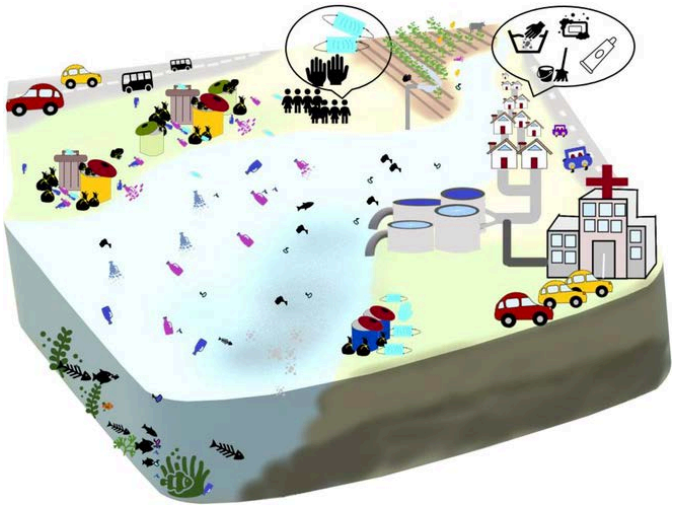
COVID-19 Impacts and Water Quality

Research challenges

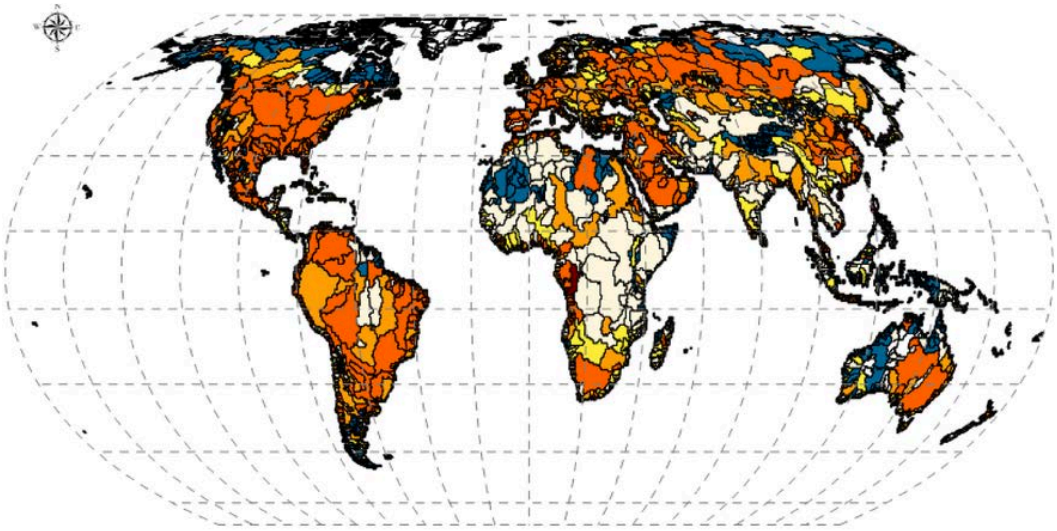
River pollution is increasing in many basins worldwide. National measures to cope with the COVID-19 crisis may influence this river pollution. In this project, we increase our understanding on the effects of COVID-19 associated measures on over 10,000 rivers in the world. We focus on the following COVID-19 measures: the increased use of hand soap (triclosan), personal protective equipment and packaging materials (plastics), painkillers (diclofenac), and reduced transportation (microplastics from car tires).



Methods

Updated version of the MARINA model (Model to Assess River Inputs of pollutaNts to seAs)

Results



Change in inputs of pollutants to rivers as a result of the impact of COVID-19 measures(%)

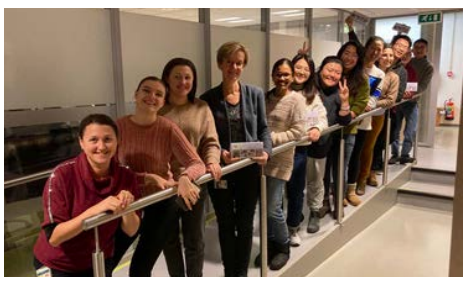
- No data
- Decreases for all pollutants
- <30% increase for all pollutants
- >30% increase for one pollutant
- >30% increase for two pollutants
- >30% increase for three pollutants
- >30% increase for four pollutants

Over half of the world's rivers experience COVID-19-associated pollution impacts.

(see Zhang et al., 2023: https://doi.org/10.1016/j.crsus.2023.100001)

AGD program:

The MARINA team



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Geopolitical tension and Water Quality

Research challenges

Wars (geopolitical crises) may influence river pollution. they do not only impact the living conditions of people, but also may reduce the availability of clean water for human needs and nature. For examples, since 24 February 2022, the Russian-Ukrainian war has impacted Ukrainian water resources may increase river pollution with untreated urban waste compared to the pre-war period. In this project, we aim to increase our understanding on the impacts of the war activities on water pollution taking multi-pollutant perspectives. We start with Ukraine and draw lessons for other countries with similar issues.

Methods and Results (examples)

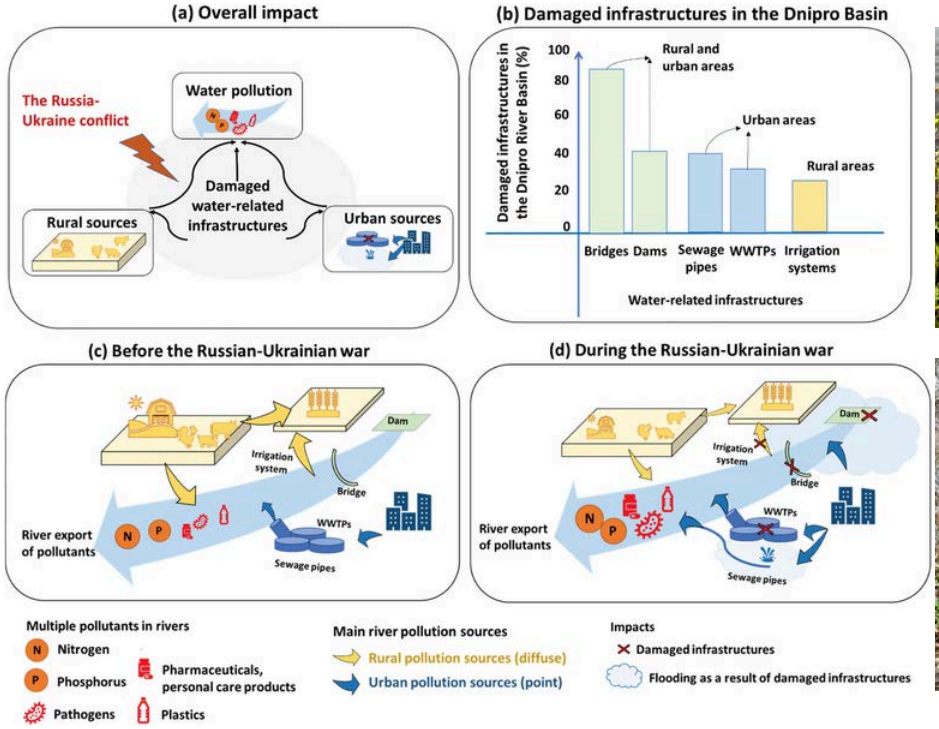

Figure showing that in the Dnipro Basin (located in Ukraine):

- River pollution is estimated to increase by 2–34% due to war-associated damaged sewage and treatment facilities;
- Untreated urban waste is responsible for 20–62% of pollutants in rivers, which was much less compared to the pre-war situation.

(see Strokal et al., 2023: https://doi.org/10.1080/1943815X.2023.2281920)

Links for more information:

- https://doi.org/10.1080/1943815X.2023.2281920
- CLIMAGRI4Ukraine project is acknoledged

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The Plastic Age and Water Quality

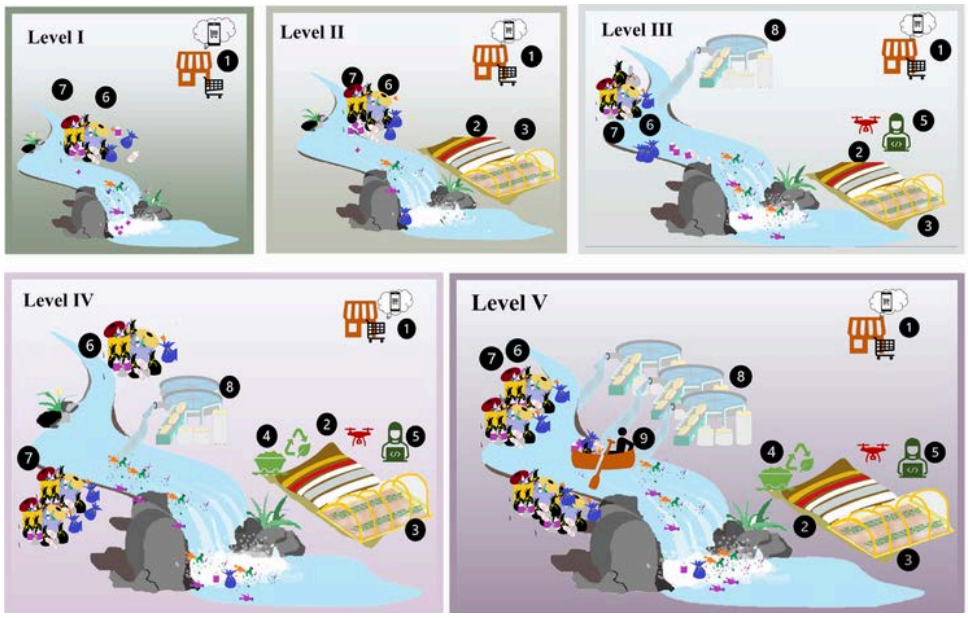
Research challenges

We live in the “Plastic Age” in which the use of plastic products has increased worldwide. This can impact water quality. Plastics in water results from various sources including urban activities (e.g., the use of personal care products) and agriculture (e.g., plastic films in crop production). The contribution of these sources in total plastic water pollution is still not well understood. In this project, we focus on understanding which sources impact the most plastic pollution, where (sub-basins) and how to reduce this pollution.

Methods

MARINA-Plastics model (Model to Assess River Inputs of pollutaNts to seAs for Plastics)

Results



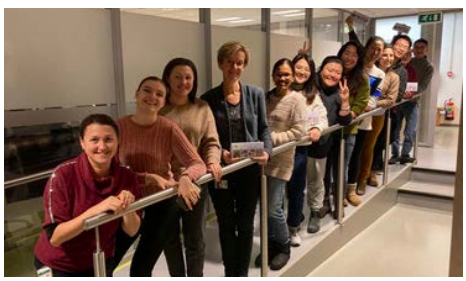
Proposed strategies to reduce plastics pollution in Chinese river basins from agricultural plastic films, mismanaged waste and sewage. Levels refer to pollution loadings from low (Level I) to high (Level V).

(see Li et al., 2023: https://doi.org/10.1016/j.crsus.2023.100001)

1. Improved plastic film quality
2. Plastic management for greenhouses
3. Plastic management for mulching
4. Action plans for plastics reduction in crop production
5. Learning in Science and Technology Backyards
6. Policies for plastic production and consumption and reduction
7. Plastic recycling and city waste management
8. Advanced technologies wastewater treatment
9. Cleanup programs

AGD program:

The MARINA team



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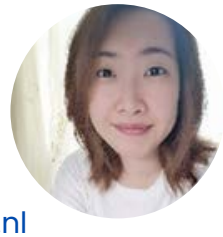

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