Using System Dynamics participatory modelling to support international river basin policy discussions:

The case of the Lielupe River Basin (Lithuania and Latvia) Water-Energy-Food-Ecosystems Nexus

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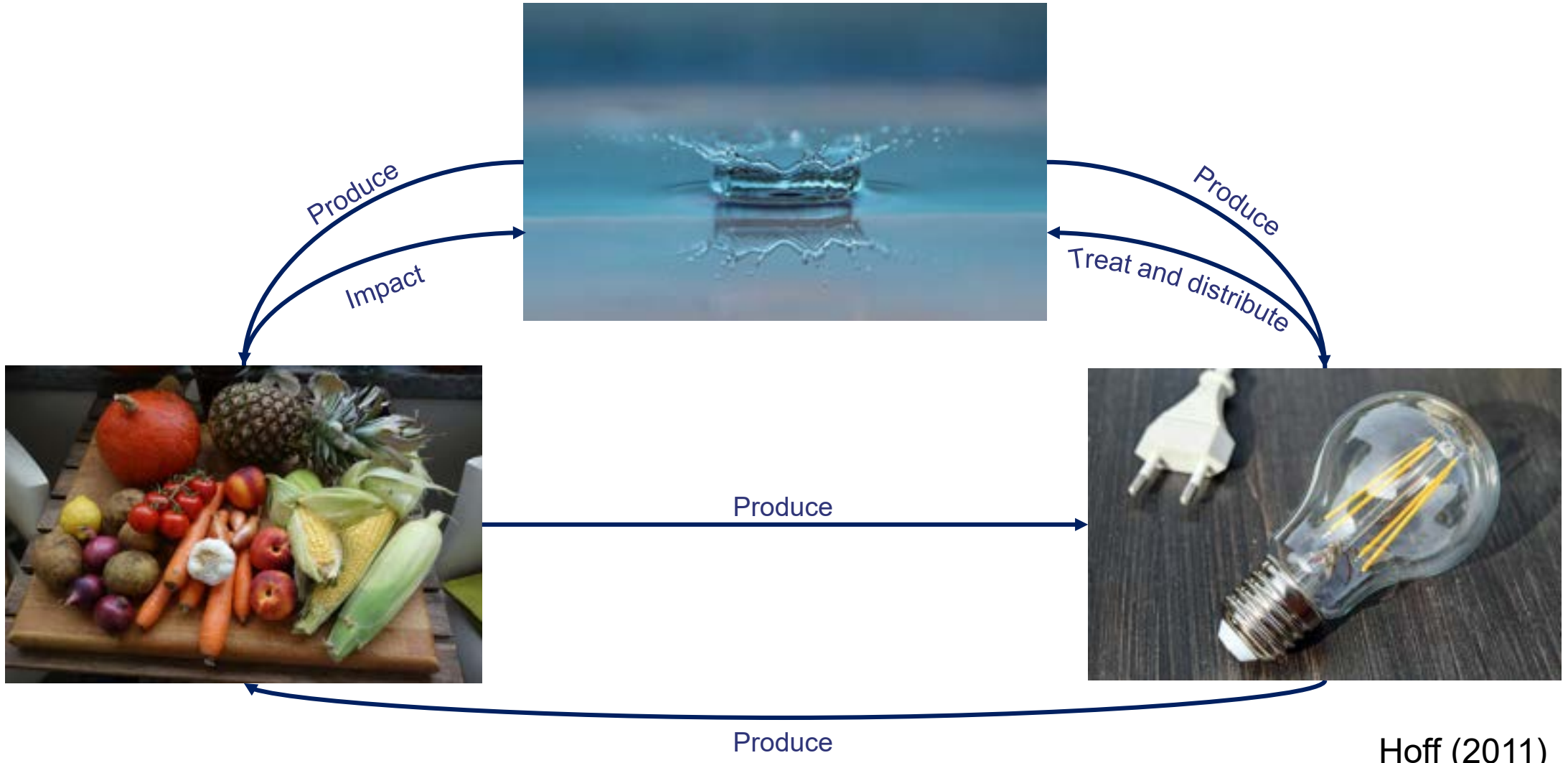
NEXOGENESIS
STREAMLINING WATER RELATED POLICIES

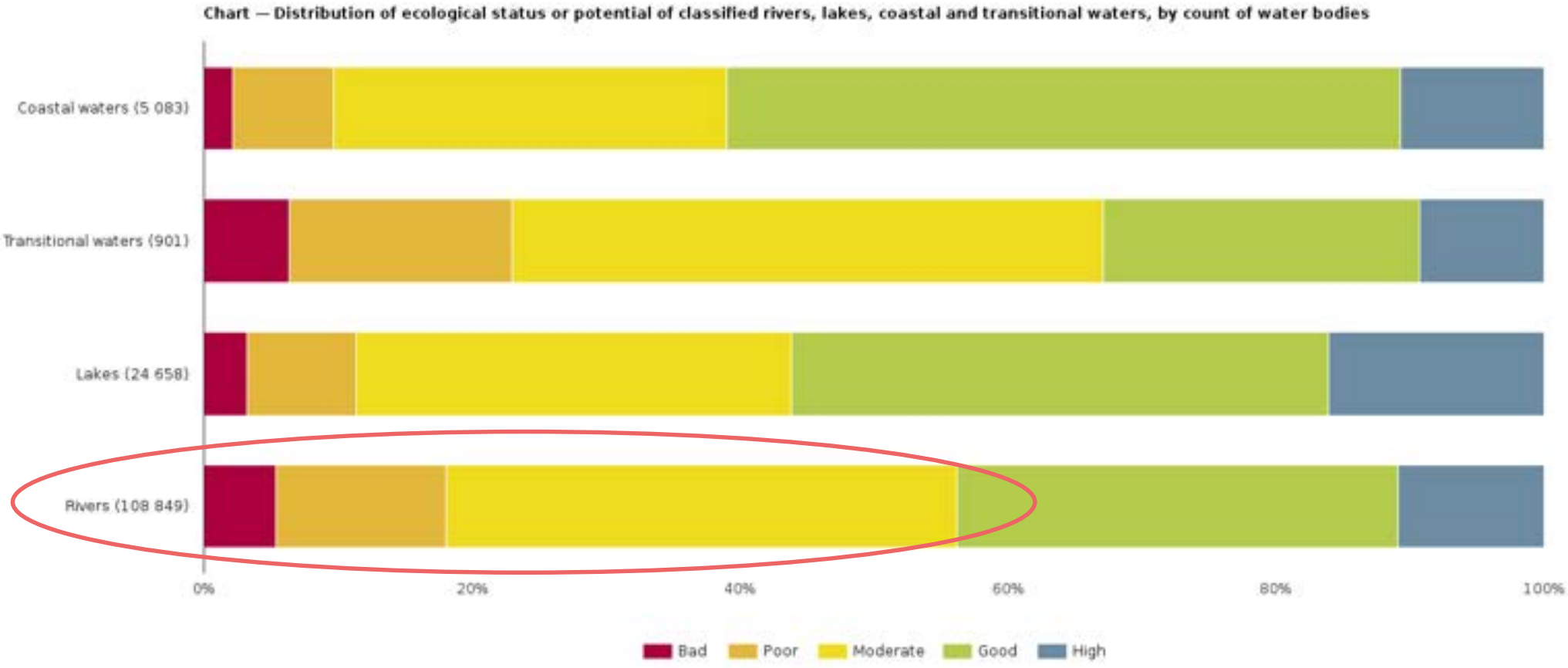
WEF Nexus



Hoff (2011)

How about the Ecosystems?

Hülsmann et al. (2019)

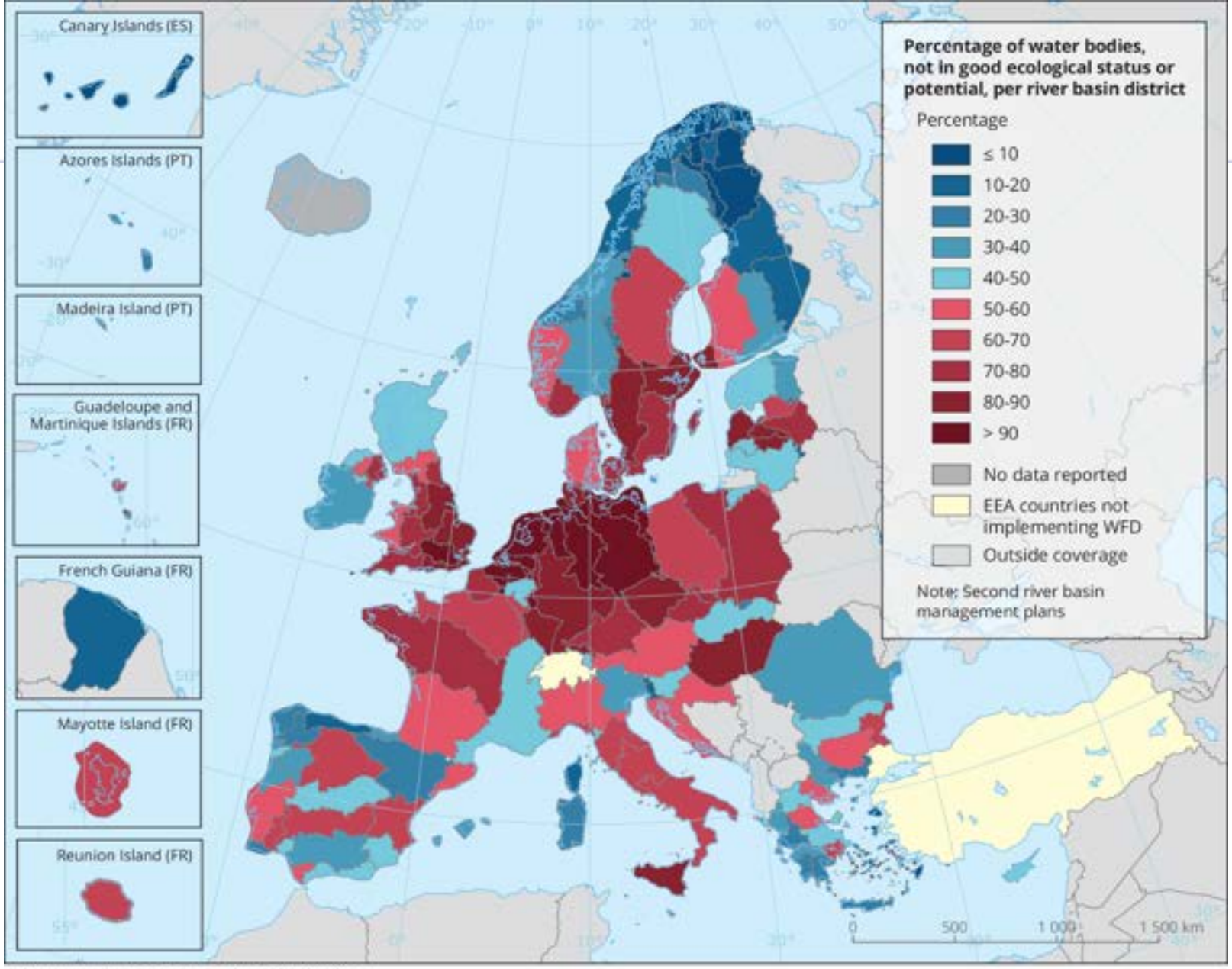


Note:
The figure is based on information reported under the Water Framework Directive as part of countries' second river basin management plans. These plans were finalised in 2015 and information was reported between 2016 and 2018. The results cover the period 2010-2015 and all surface water bodies, i.e. rivers, lakes, and coastal and transitional waters, in the 27 Member States (EU-27) plus Norway and the United Kingdom.

Data sources:
WISE Water Framework Directive Database provided by Directorate-General for Environment (DG ENV)

Source: EEA, 2021

https://www.eea.europa.eu/data-and-maps/daviz/distribution-of-ecological-status-or-5#tab-chart_1



Reference data: ©ESRI | ©EuroGeographics

Source: EEA, 2021

https://www.eea.europa.eu/data-and-maps/figures/proportion-of-classified-surface-water-7

https://unsplash.com/photos/men-rowing-boat-H3htK85wwnU

Microsoft Bing Designer - Generated with AI

https://unsplash.com/photos/person-writing-bucket-list-on-book-RLw-UC03Gwc

https://unsplash.com/photos/cw-cj_nFa14

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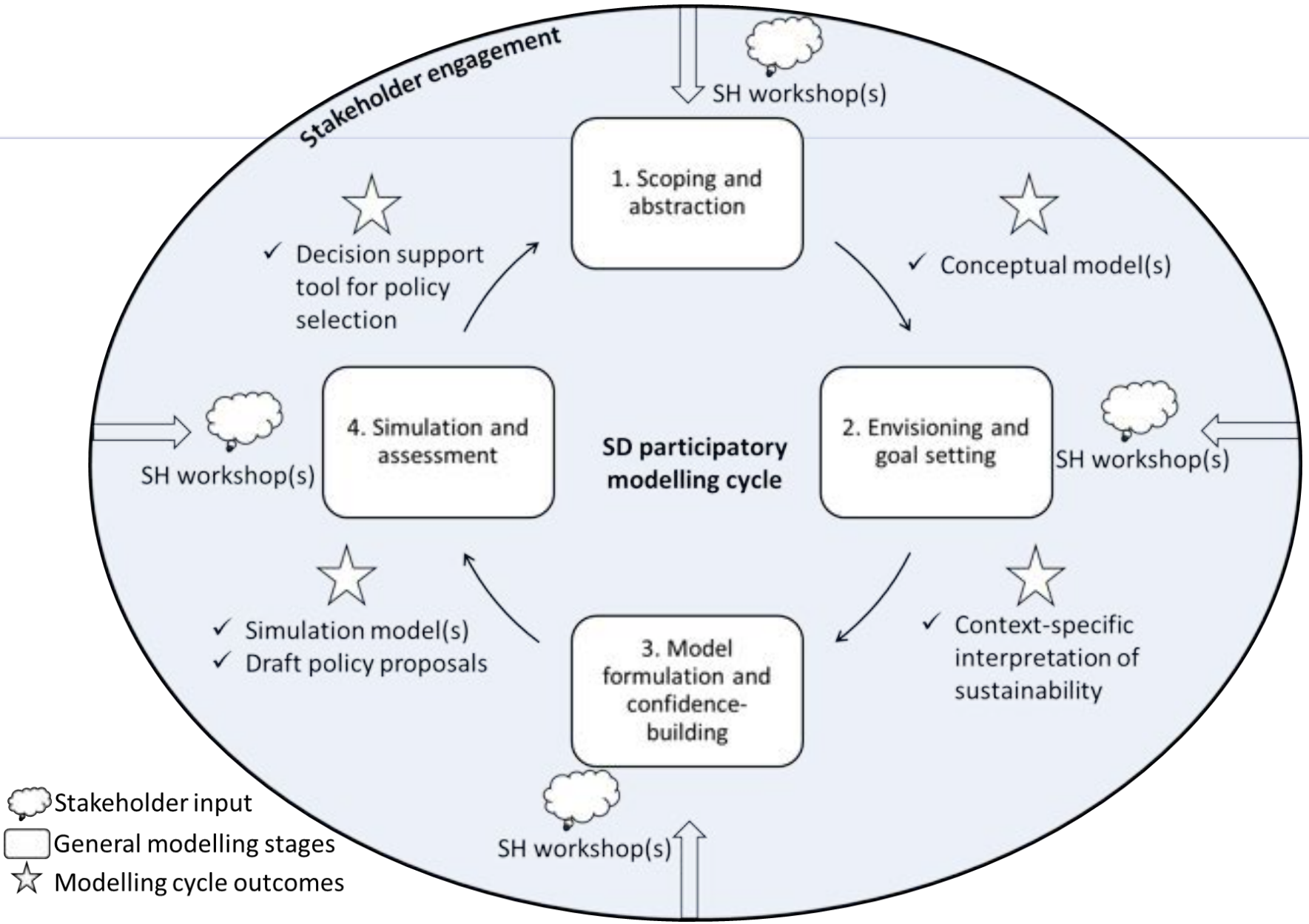
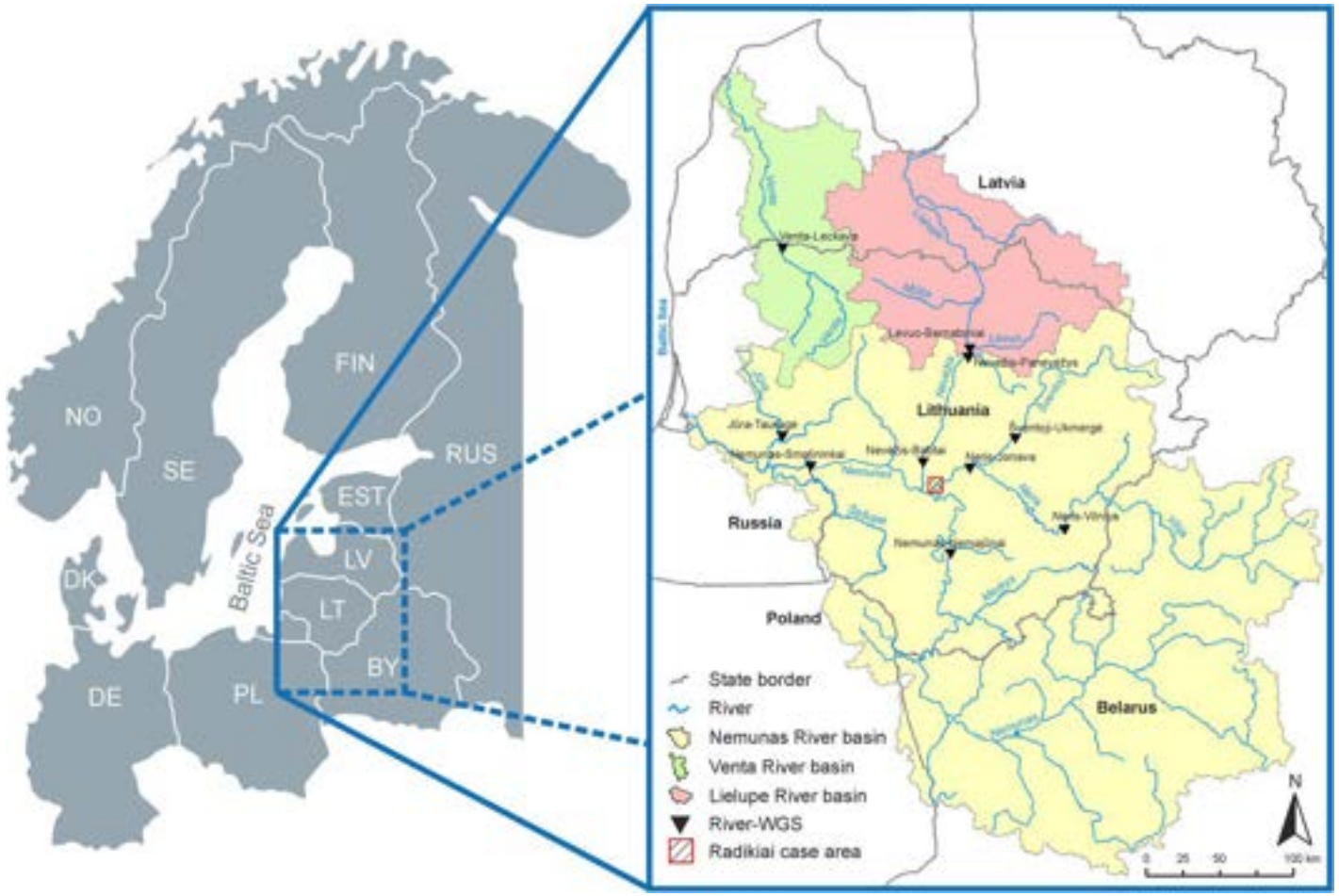


Adapted from Videira et al. (2019)

Case study – Lielupe River Basin

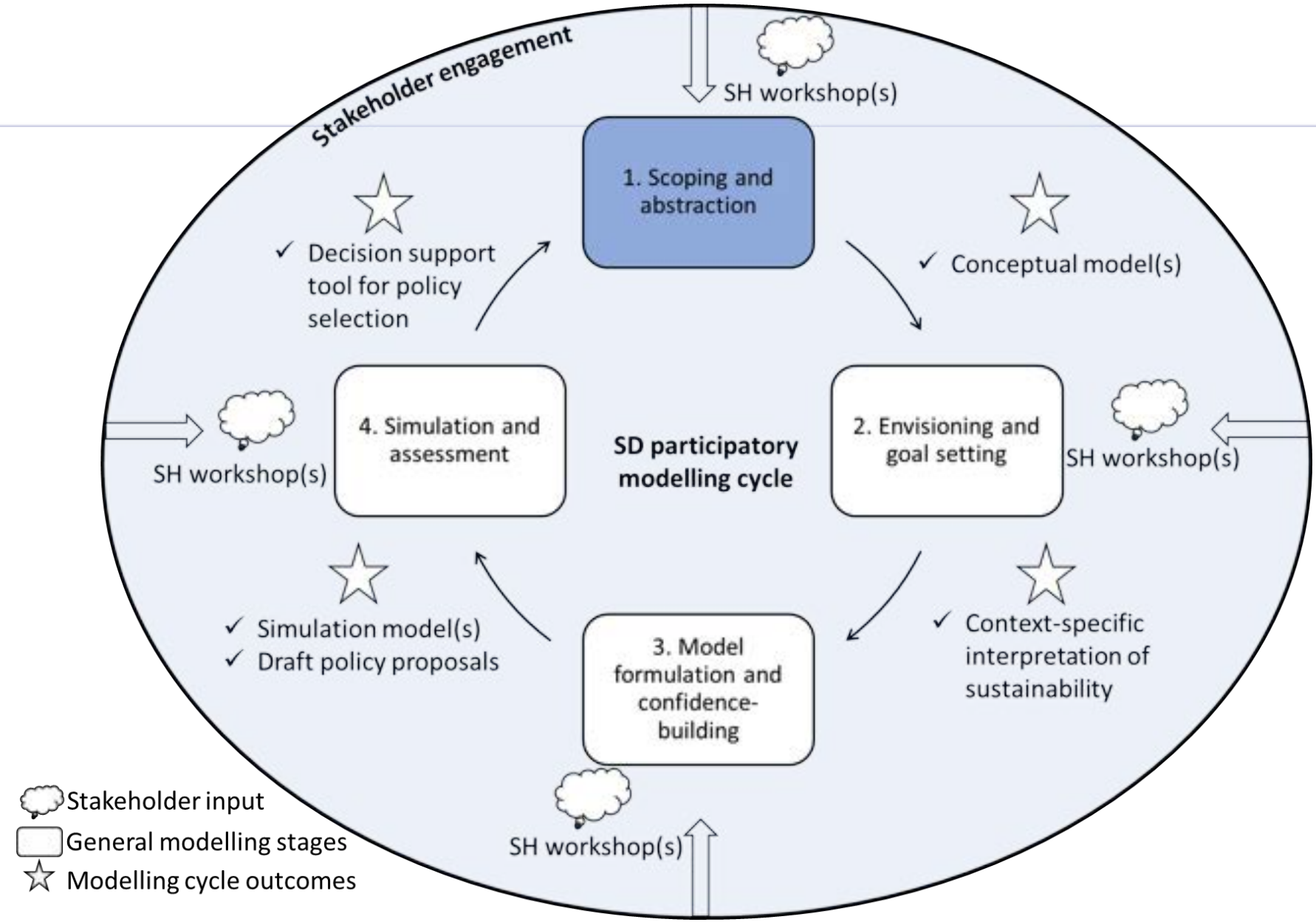


Meilutytė-Lukauskienė et al. (2022)

- **Area**: The LRB covers approximately 17,800 km², split nearly equally between Latvia (8,850 km²) and Lithuania (8,940 km²) i.e. about 14% of Latvia's and 16% of Lithuania's total area.
- **Course**: From Bauskė, the Lielupe River flows 119 km into the Gulf of Riga.
- **Mean Flow**: The Lielupe River has a mean annual flow of 3,540 Mm³/year (112 m³/s).

Case study – Lielupe River Basin

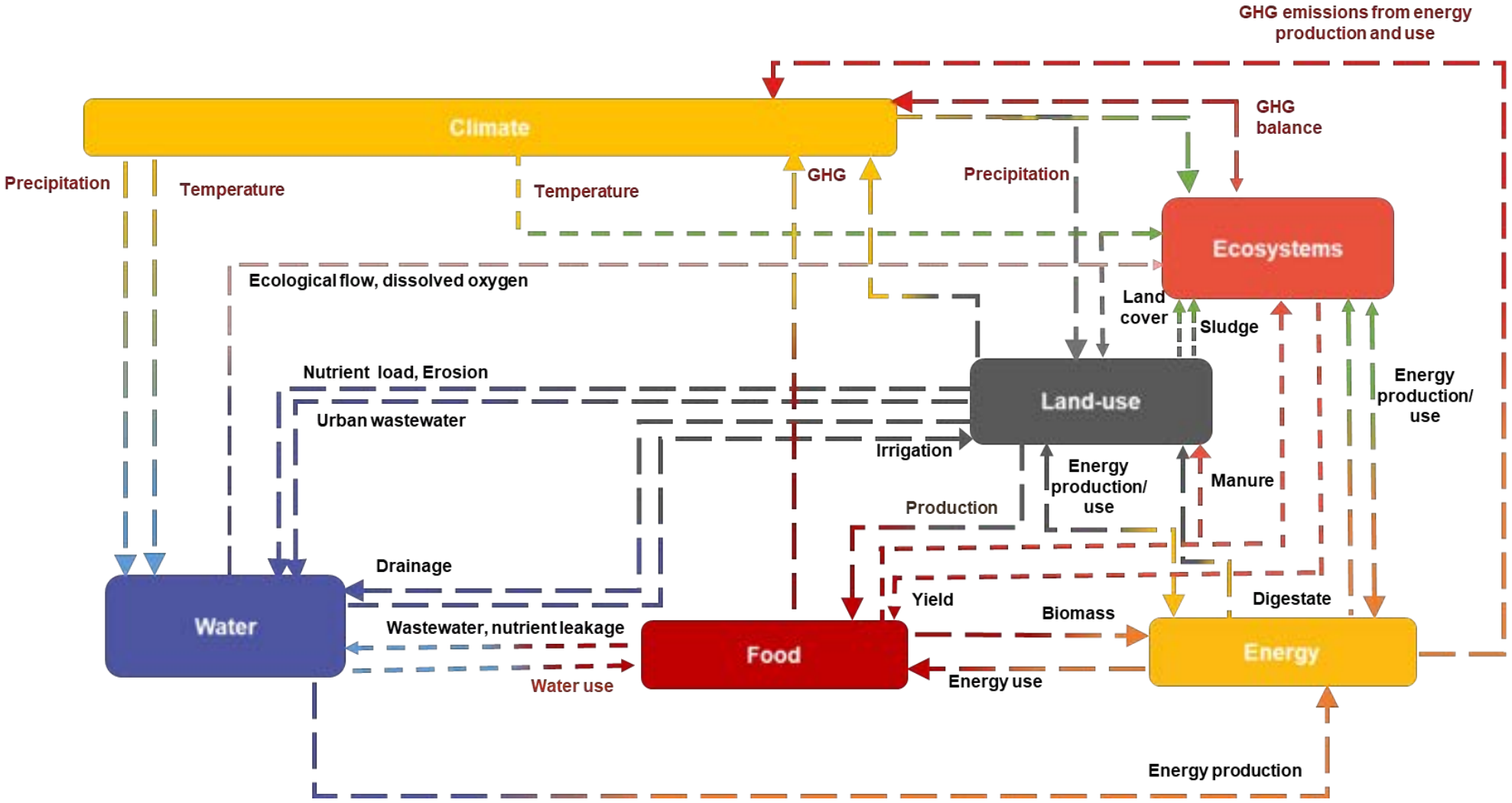
https://nexogenesis.eu/case-study-2-lielupe-river-basin/


Stakeholder engagement
SH workshop(s)
1. Scoping and abstraction
✓ Decision support tool for policy selection
✓ Conceptual model(s)
SH workshop(s)
4. Simulation and assessment
SD participatory modelling cycle
2. Envisioning and goal setting
SH workshop(s)
✓ Simulation model(s)
✓ Draft policy proposals
✓ Context-specific interpretation of sustainability
3. Model formulation and confidence-building
SH workshop(s)
Stakeholder input
General modelling stages
Modelling cycle outcomes

Stakeholder engagement

Workshop	1
Date	10/02/2022
Location	Online
Connection with a participatory modelling cycle	Scoping and abstraction
Number of participants	33
Workshop format	Online
Facilitation approach	Small group discussions
Driving questions	• Which are the main Nexus issues in the basin? • How do current policies affect Nexus interlinkages?
Inputs	Early conceptual map
Outputs	• Identification of the key Nexus issues in the basin • Refined conceptual map

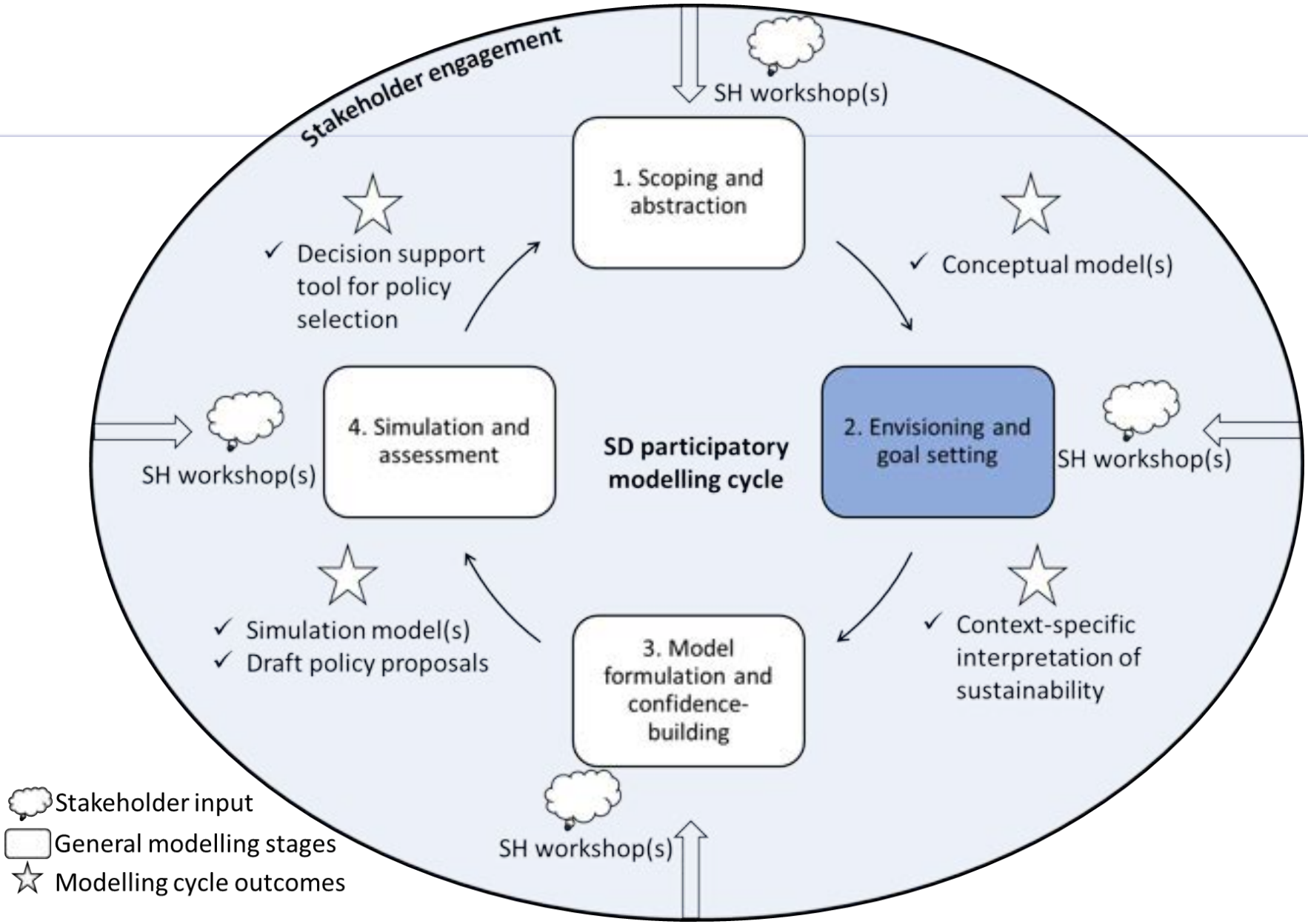
Conceptual system map as input for discussion



Sušnik et al. (2021)

https://www.esa.int/ESA_Multimedia/Images/2010/07/Bloom-filled_Baltic

Source: Limburg et al., 2016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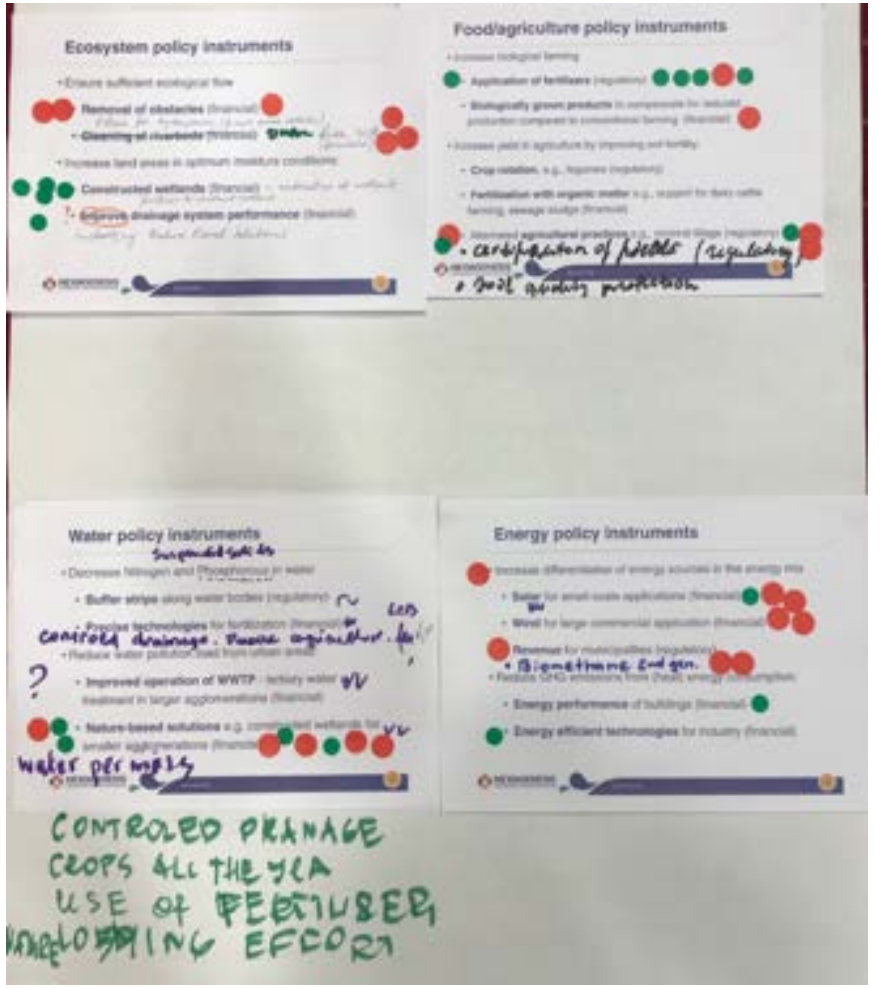
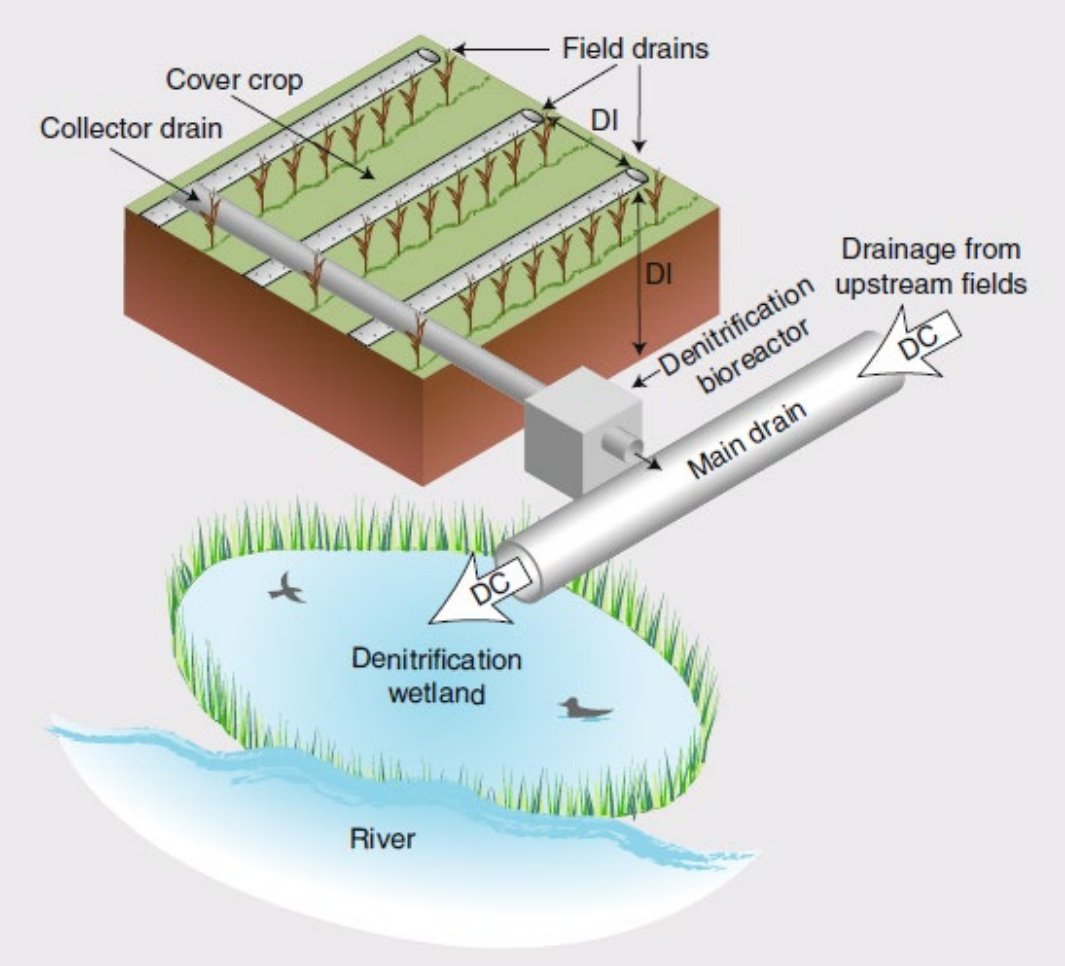
Envisioning and goal setting

Workshop	2	3
Date	02/11/2022	15/06/2023
Location	Riga, LV	Vilnius, LT
Connection with a participatory modelling cycle	Envisioning	Envisioning
Number of participants	10	10
Workshop format	In person	In person
Facilitation approach	Brainstorm policy alternatives for different Nexus sectors	• World Café • Plenary discussion • Policies prioritisation
Driving questions	Which policies are needed in the basin?	How to improve the current river basin situation?
Inputs	Early conceptual map	Draft policies by sector
Outputs	Draft CLD	Prioritised Nexus policies (sectors) A context-specific definition of sustainability

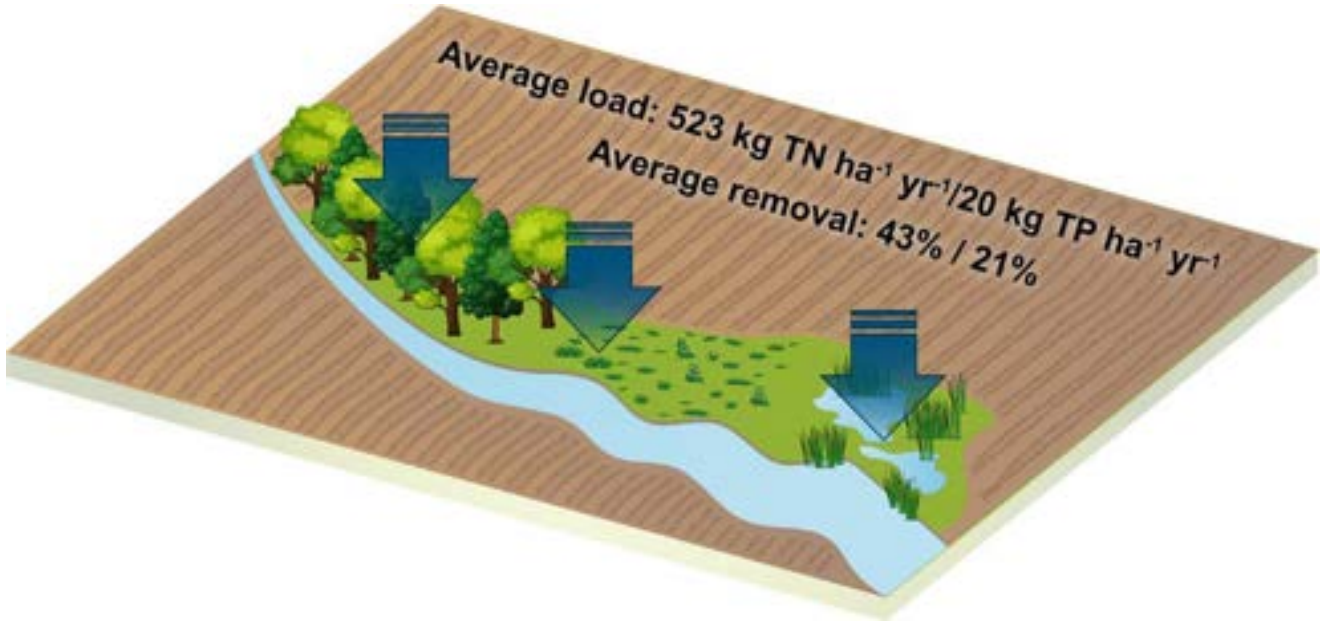
Workshop 2 - Riga, LV

Workshop 3, Vilnius, LT

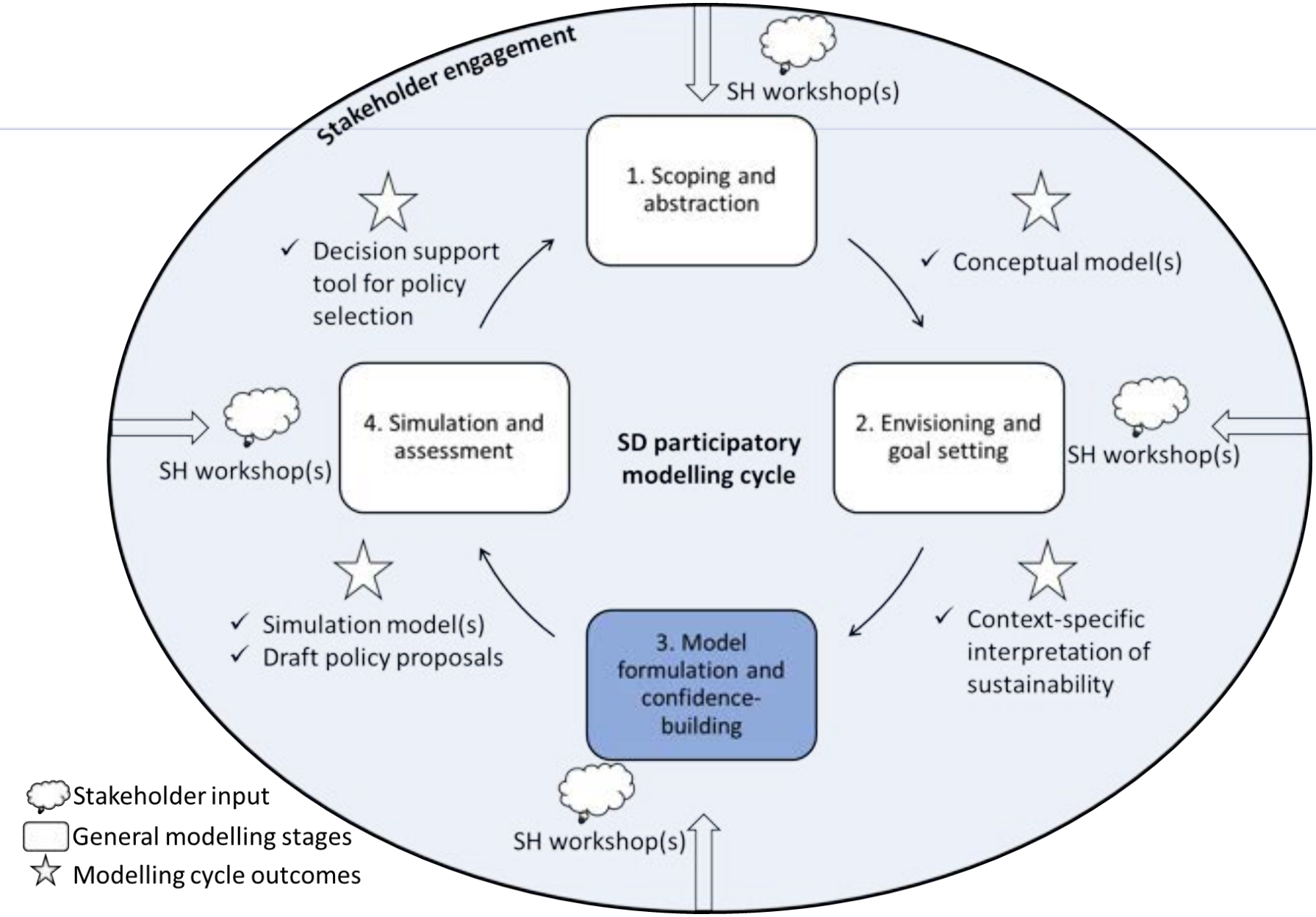

Ecosystem policy instruments
Food/agriculture policy instruments
Water policy instruments
Energy policy instruments
CONTROLED DRAINAGE
CROPS ALL THE YEA
USE OF FERTILISER



Castellano et al. (2019)



Walton et al. (2020)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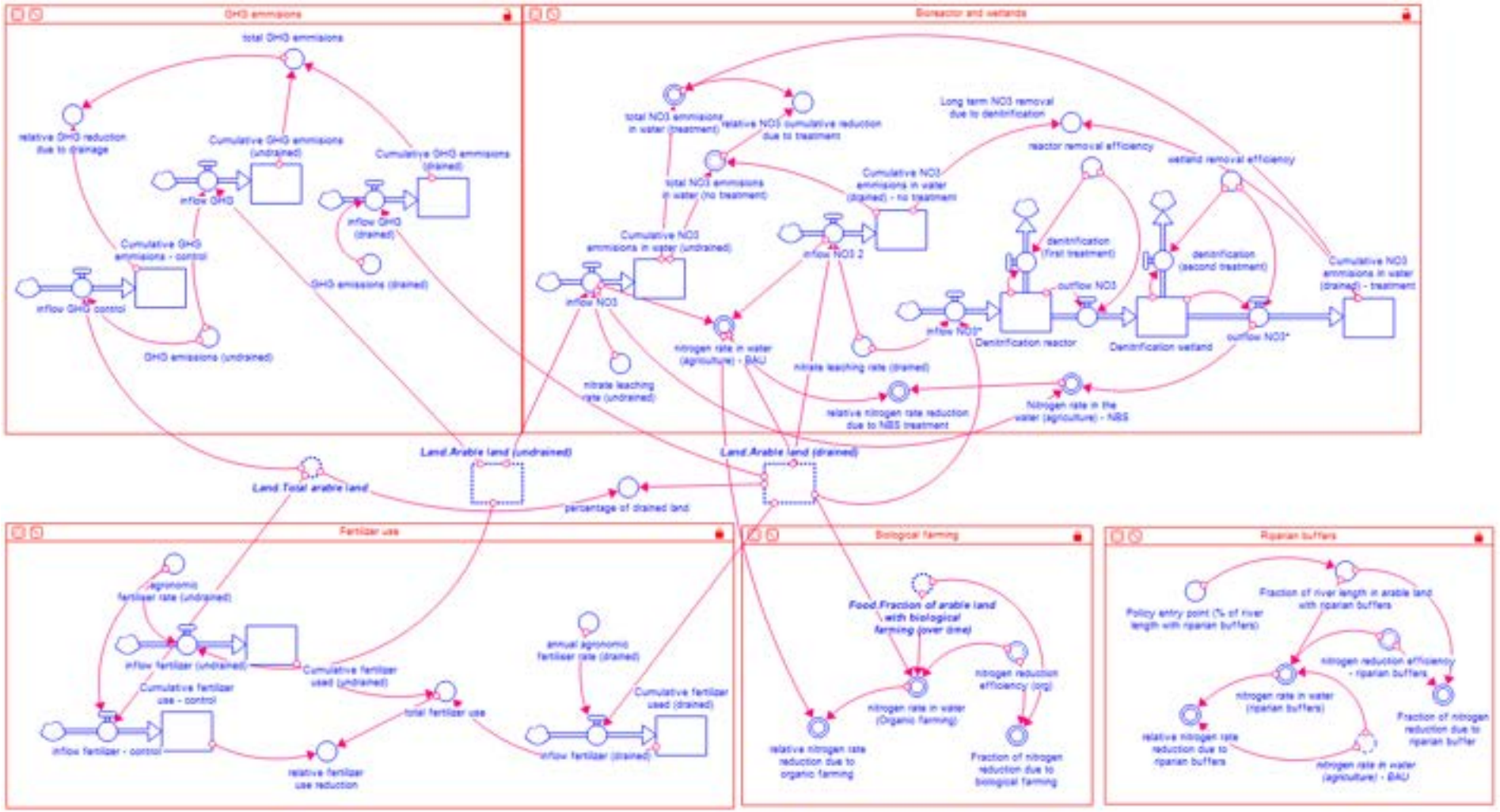
Stakeholder input
General modelling stages
Modelling cycle outcomes

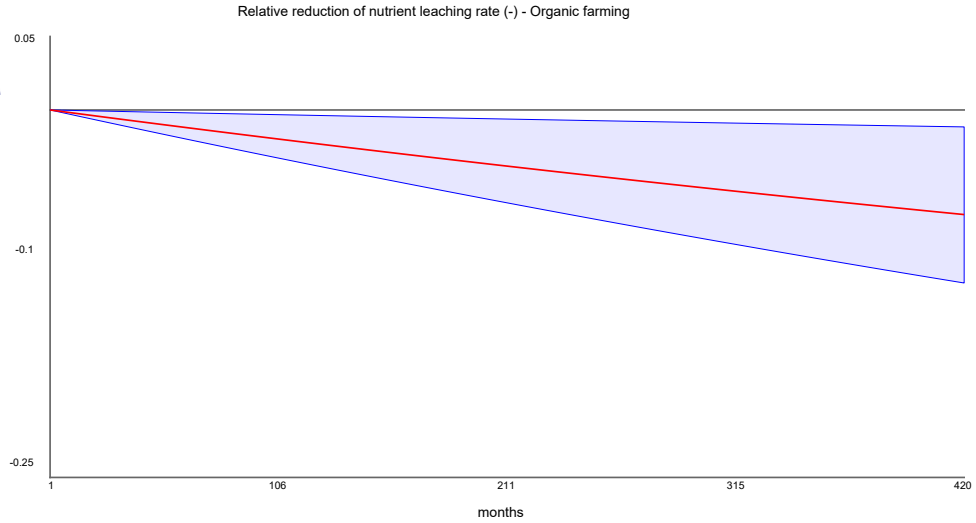
Stakeholder participation

Workshop	4
Date	06/02/2024
Location	Riga, LV
Connection with a participatory modelling cycle	Model formulation and confidence building
Number of participants	18
Workshop format	In person
Facilitation approach	Discussion about the preliminary results of the model Q&A session - modelling capabilities, assumptions and limitations
Driving questions	• Is this model useful to understand the Nexus issues in the basin? • How do you prefer to interact with a simulation model of the river basin?
Inputs	Simulation model results
Outputs	Stakeholder feedback and requests for: updating the model and designing a DSS to use it

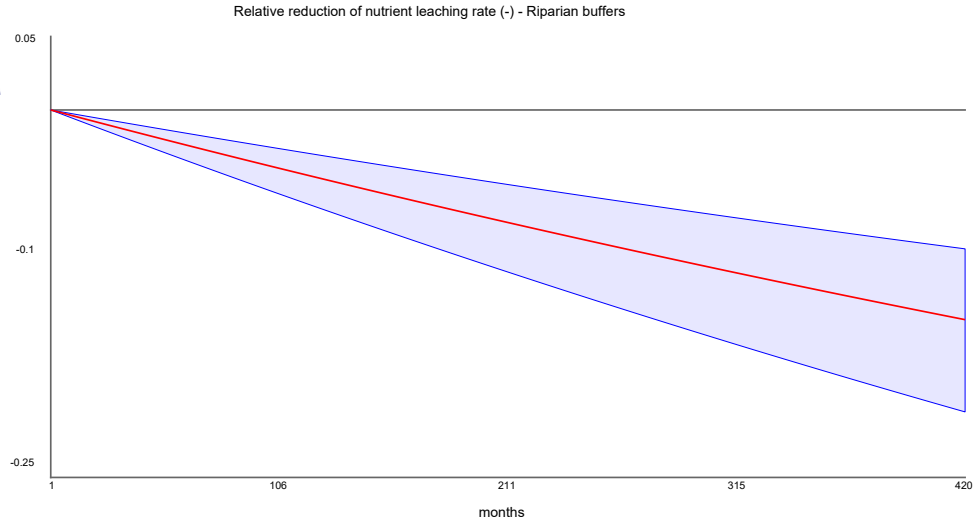

Discussion points


GHG emmisions
total GHG emmisions
relative GHG reduction due to drainage
Cumulative GHG emmisions (undrained)
Cumulative GHG emmisions (drained)
inflow GHG
inflow GHG (drained)
Cumulative GHG emmisions - control
inflow GHG control
GHG emissions (drained)
GHG emissions (undrained)
Bioreactor and wetlands
total NO3 emmisions in water (treatment)
relative NO3 cumulative reduction due to treatment
Long term NO3 removal due to denitrification
reactor removal efficiency
wetland removal efficiency
total NO3 emmisions in water (no treatment)
Cumulative NO3 emmisions in water (drained) - no treatment
Cumulative NO3 emmisions in water (undrained)
inflow NO3 2
denitrification (First treatment)
denitrification (second treatment)
Cumulative NO3 emmisions in water (drained) - treatment
inflow NO3
outflow NO3
inflow NO3*
outflow NO3*
Denitrification reactor
Denitrification wetland
nitrogen rate in water (agriculture) - BAU
nitrate leaching rate (drained)
nitrate leaching rate (undrained)
relative nitrogen rate reduction due to NBS treatment
Nitrogen rate in the water (agriculture) - NBS
Land.Arable land (undrained)
Land.Arable land (drained)
Land.Total arable land
percentage of drained land
Fertilizer use
agronomic fertilizer rate (undrained)
inflow fertilizer (undrained)
Cumulative fertilizer used (undrained)
Cumulative fertilizer use - control
annual agronomic fertilizer rate (drained)
Cumulative fertilizer used (drained)
total fertilizer use
inflow fertilizer - control
inflow fertilizer (drained)
relative fertilizer use reduction
Biological farming
Food.Fraction of arable land with biological farming (over time)
nitrogen reduction efficiency (org)
nitrogen rate in water (Organic farming)
relative nitrogen rate reduction due to organic farming
Fraction of nitrogen reduction due to biological farming
Riparian buffers
Policy entry point (% of river length with riparian buffers)
Fraction of river length in arable land with riparian buffers
nitrogen reduction efficiency - riparian buffers
nitrogen rate in water (riparian buffers)
Fraction of nitrogen reduction due to riparian buffer
relative nitrogen rate reduction due to riparian buffers
nitrogen rate in water (agriculture) - BAU

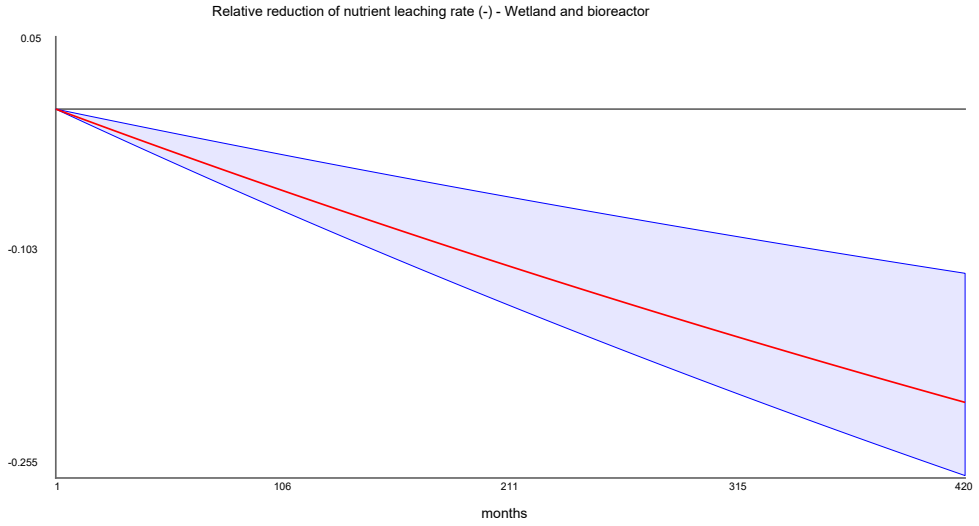
A

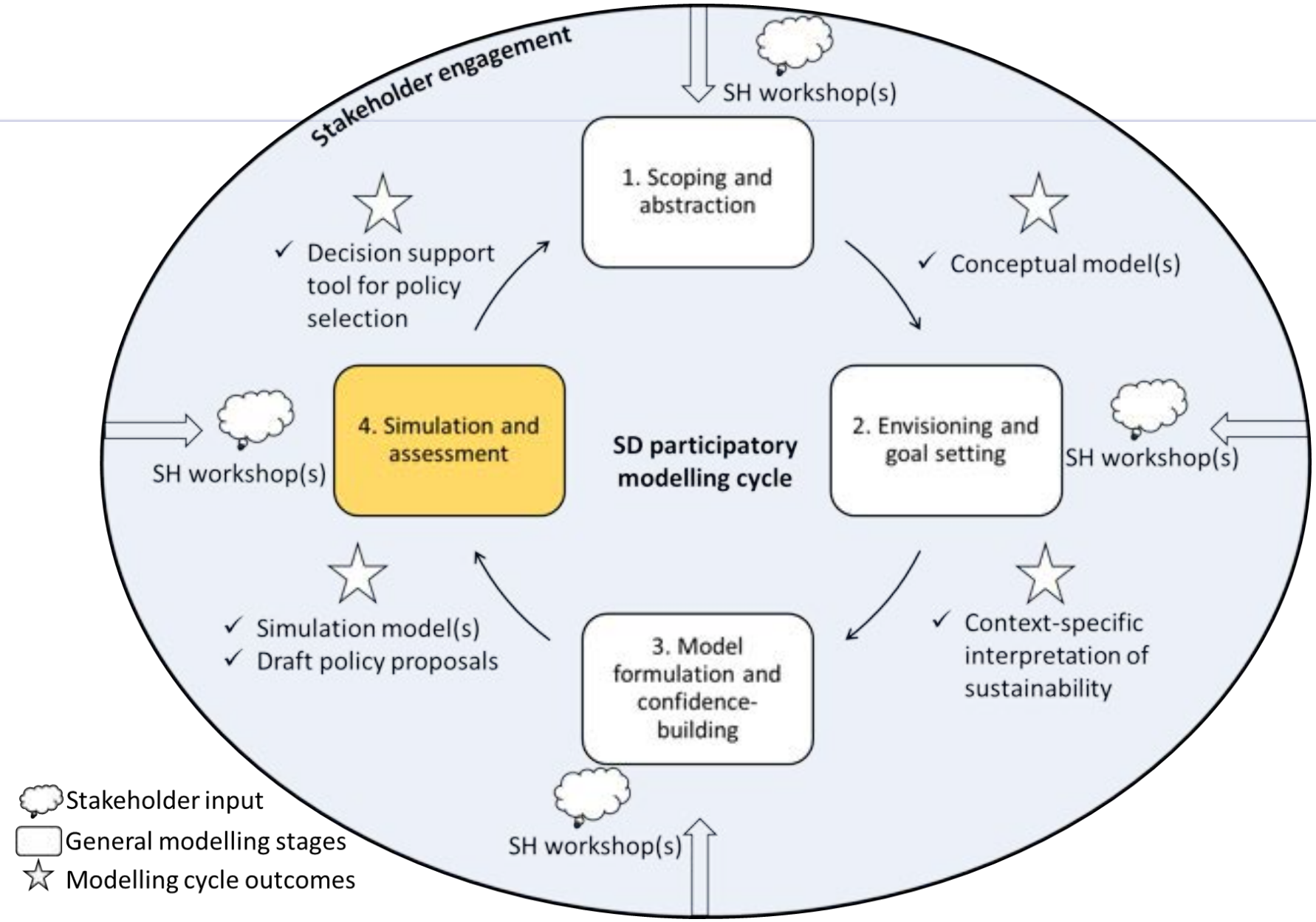

Relative reduction of nutrient leaching rate (-) - Organic farming
0.05
-0.1
-0.25
1
106
211
315
420
months

B


Relative reduction of nutrient leaching rate (-) - Riparian buffers
0.05
-0.1
-0.25
1
106
211
315
420
months

C


Relative reduction of nutrient leaching rate (-) - Wetland and bioreactor
0.05
-0.103
-0.255
1
106
211
315
420
months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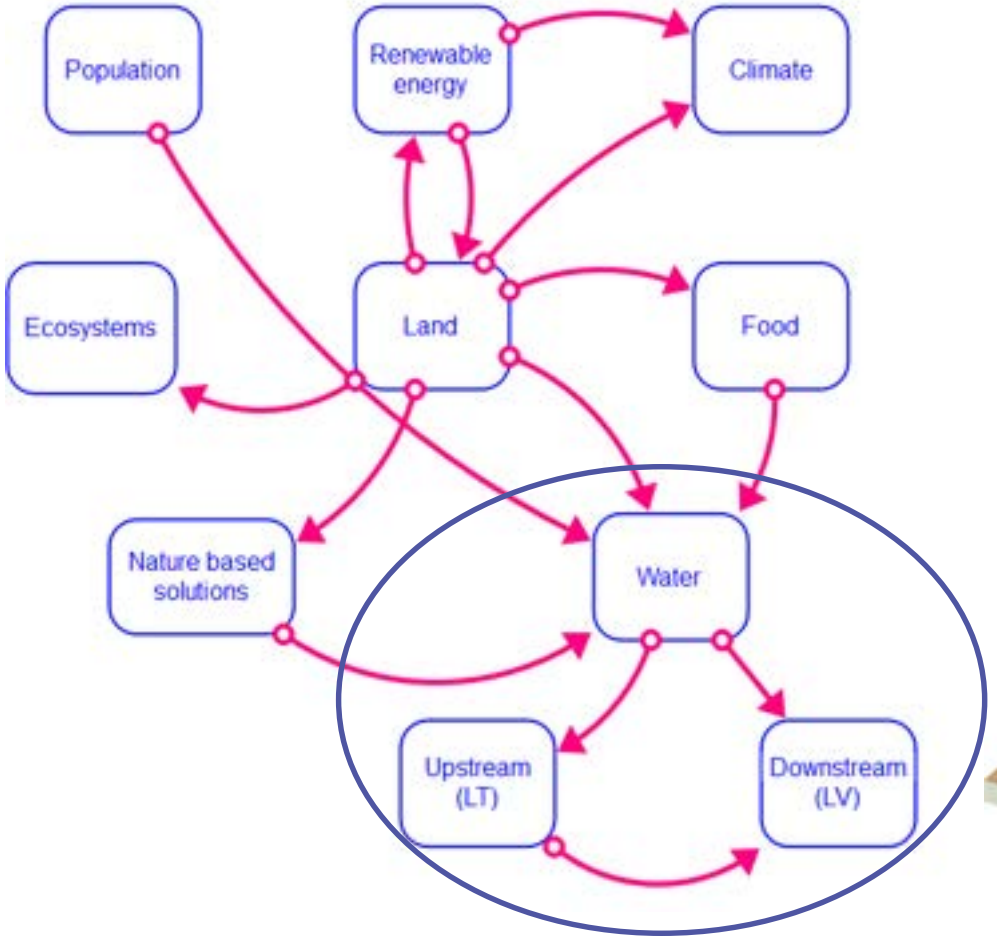
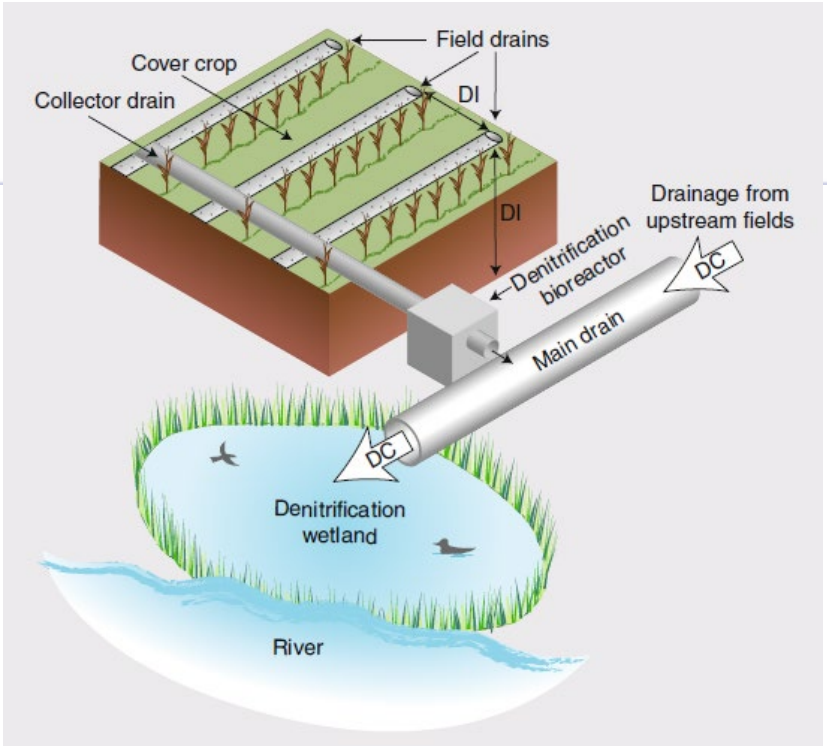
Modelling cycle outcomes

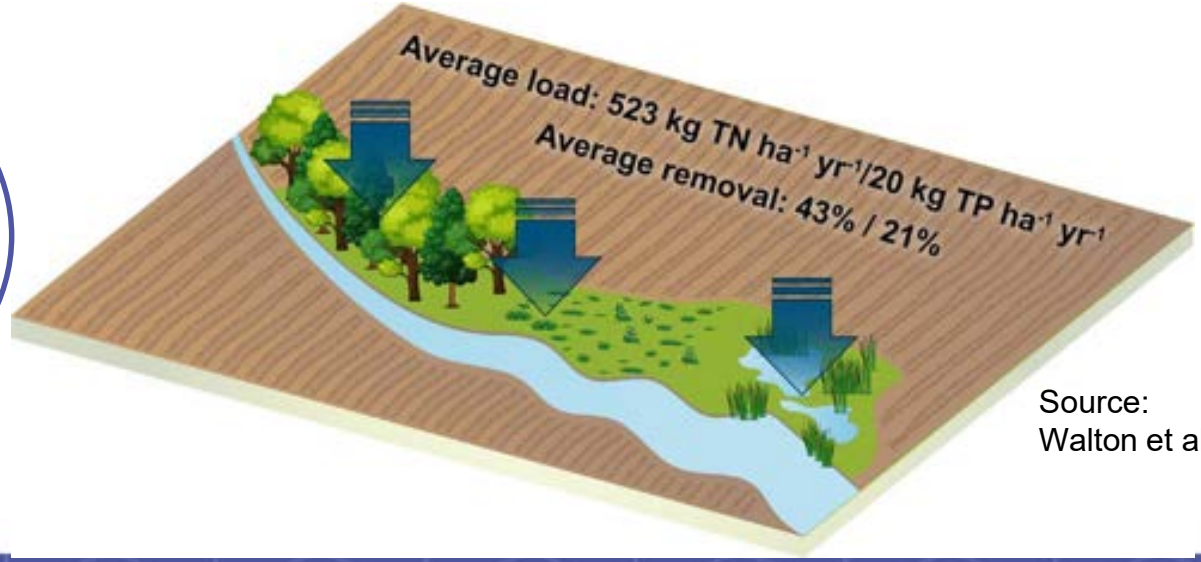
Stakeholder participation

Workshop	5
Date	October 2, 2024
Location	Riga, LV
Connection with a participatory modelling cycle	Simulation and assessment
Number of participants	-
Workshop format	In person
Facilitation approach	• Serious game workshop (roleplay and policy exploration) • Small group discussion • Plenary discussion
Driving questions	• How did your understanding of the situation changed after using the decision support tool? • Is this tool useful for keep discussing Nexus policies with other stakeholders and decision makers • Does this tool create opportunities for further collaboration in the basin
Inputs	Decision support tool
Outputs	Stakeholder feedback and requests for: improving the experience of using the decision support tool.





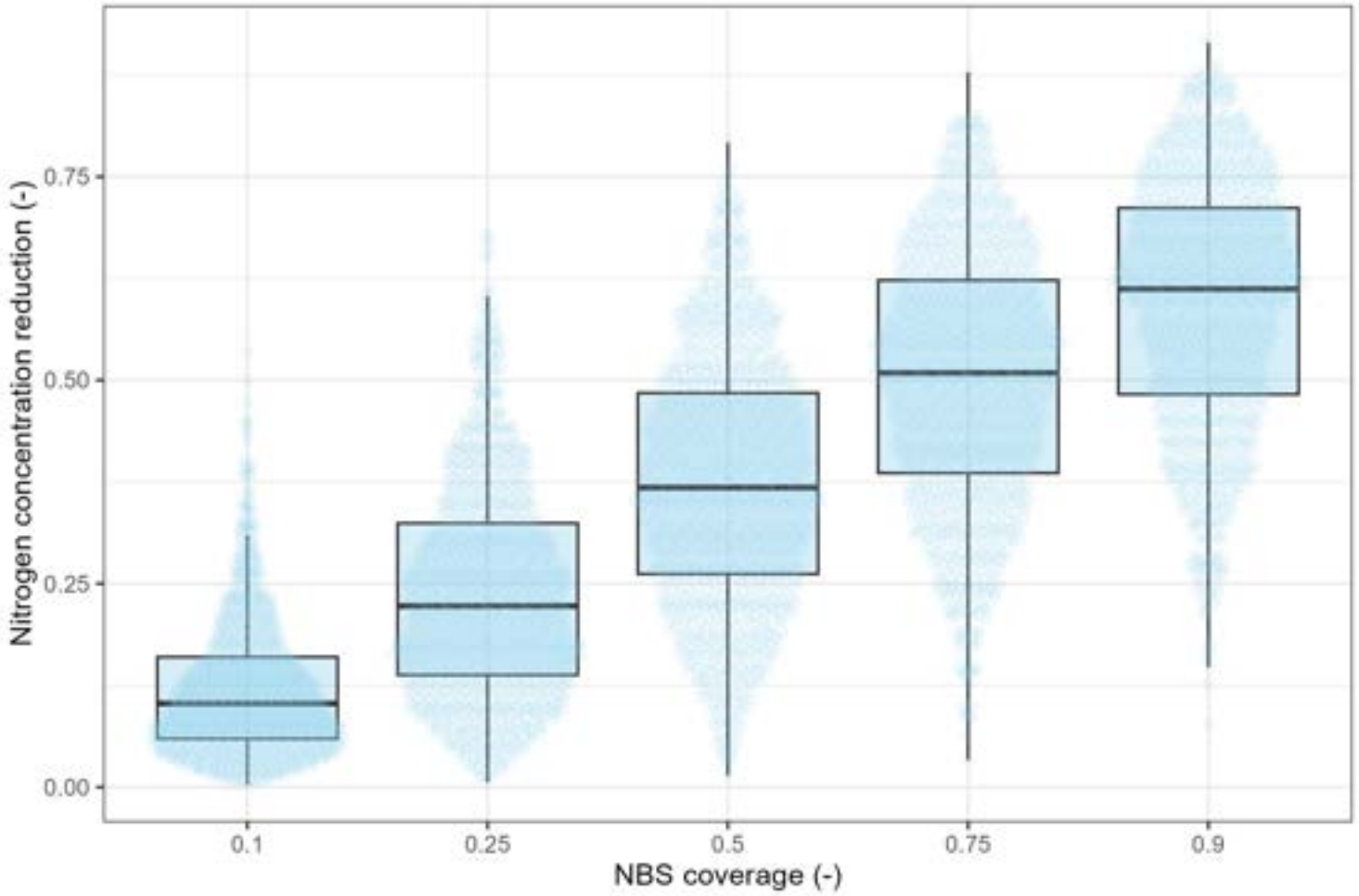
Source:
Castellano et al. (2019)



Source:
Walton et al. (2020)

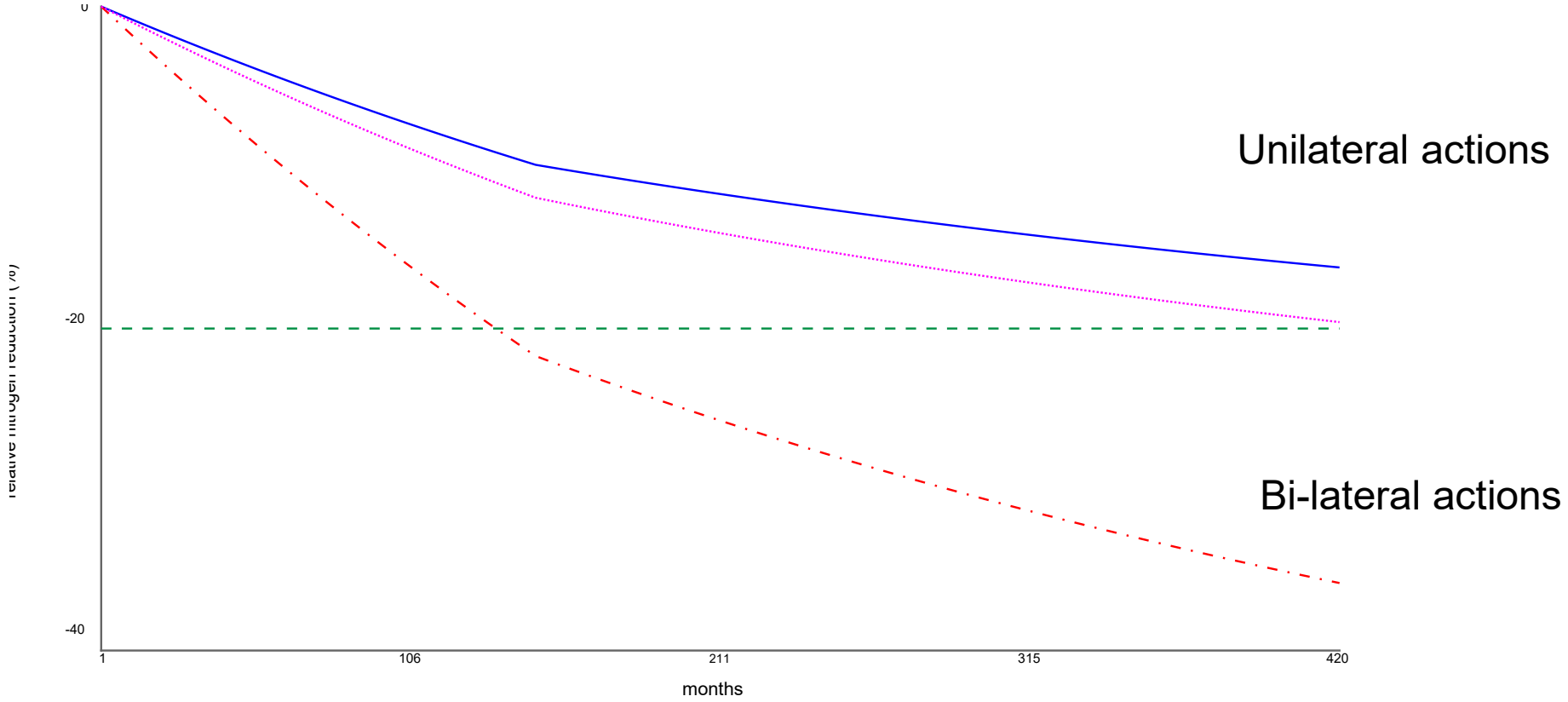
Learning insights for the workshop - scale

River basins largely dominated by agricultural land use require large-scale implementation of nature-based solutions (e.g. wetlands, vegetated strips) to significantly reduce nutrient pollution.



Learning insights for the workshop - cooperation

Improving water quality indicators in transboundary river basins requires upstream-downstream cooperation.



Conclusions

- A participatory SD modelling cycle is a powerful way to conceptualise and structure stakeholder engagement and modelling outcomes in complex WEFE Nexus discussions
- Stakeholder workshops are key events that have shaped the modelling outcomes (e.g. scoping and extension) in the case study
- Preliminary policy assessments also show alternative ways and their expected performance to move forward sustainability visions in the basin (e.g. implementing NBS to control nitrogen pollution).
- Integrating SD in a river basin policy decision support tool is a promising way to facilitate long-term and collaborative policy discussions in the river basin.

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Thanks for your attention!

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101003881.

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