LIFE Platform meeting
FOCUS ON WATER RESILIENCE STRATEGY

LIFE Strategic Integrated Projects implementing River Basin Management Plans practices

Day 2.

Workshop

DIGITALISATION / INNOVATION smart water, use of AI, data collection and management

Elina Bennetsen

15 October 2025

Brussels

This meeting is organised by

Use of remote sensing and hybrid modeling for decision support related to hydromorphology and ecology

Project title: LIFE Belini - action C6
Developing an aquatic ecological model

RBMP targeted: 3d RBMP

Beneficiary/ies: Flanders Environment Agency, 8 partners

Start and end dates: 2016-2026

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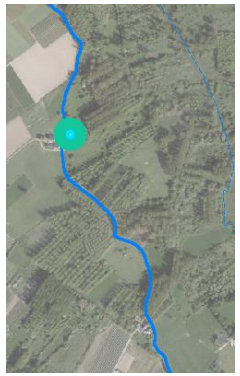
belini

FLANDERS
ENVIRONMENT AGENCY

How to reach a good biological state?



Present state

Ecologisch(e) Toestand/Potentieel

* **Evaluatie biologische elementen:** Ontoereikend

fytobenthos	fytoplankton	macrofyten	macroinvertebraten	vis
Goed	n.r.	Ontoereikend	Matig	Matig

* **Evaluatie biologie ondersteunende fysisch-chemische elementen:** Ontoereikend **Toetstype:** Bg

Parameter	Evaluatie	Toets		Klassegrenzen	Eenheid
pH	Zeer goed	minimum	2012	>=6.5,<=8.5	-
Geleidbaarheid (20°C)	Matig	90 percentiel	2012	> 600,<=1000	µS/cm
pH	Zeer goed	maximum	2012	>=6.5,<=8.5	-
Temperatuur	Zeer goed	maximum	2012	<=23.0	°C
Zuurstof, opgeloste	Goed	10 percentiel	2012	>=6,< 8	mg/L
Fosfor, totaal	Ontoereikend	zomergemiddelde	2012	> 0.35,<=0.70	mgP/L
Stikstof, totaal	Matig	zomergemiddelde	2012	> 4,<=8	mgN/L

* **Evaluatie specifiek verontreinigende stoffen:** Slecht

* **Evaluatie ecologische toestand:** Ontoereikend

Desirable state

Need for an ecological model

Good biological status
What does this represent?

Need for a *transparant* ecological model

Actions → Pressures → Abiotic conditions → Ecology → Biological quality EQR

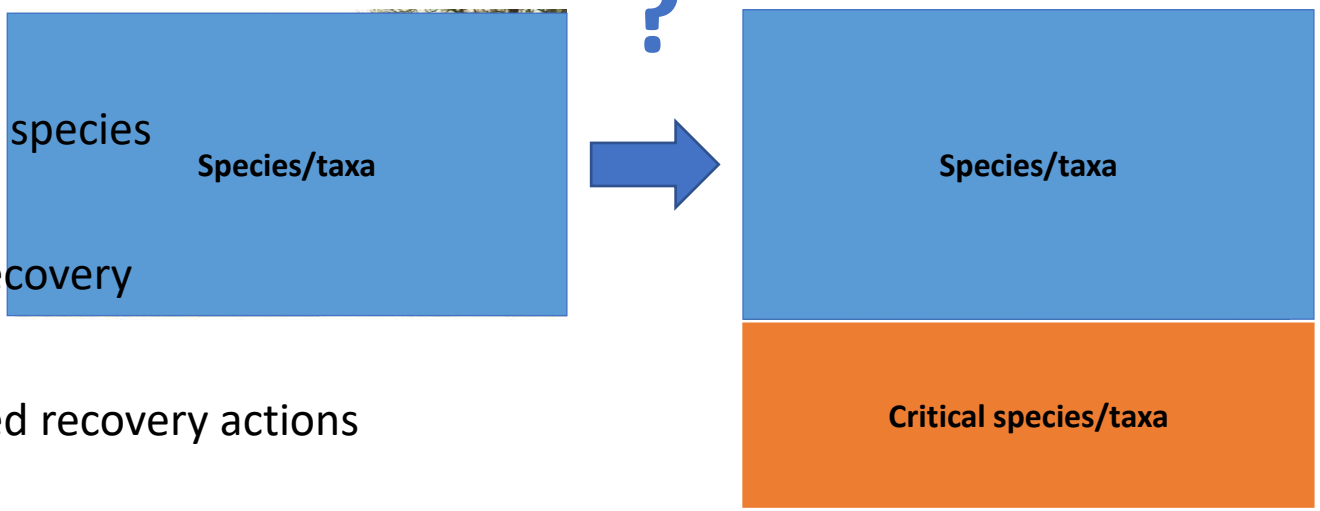
Present state **Desirable state**

Identification of desirable state

Reason absence critical species

Linking variables and recovery

Simulations of combined recovery actions

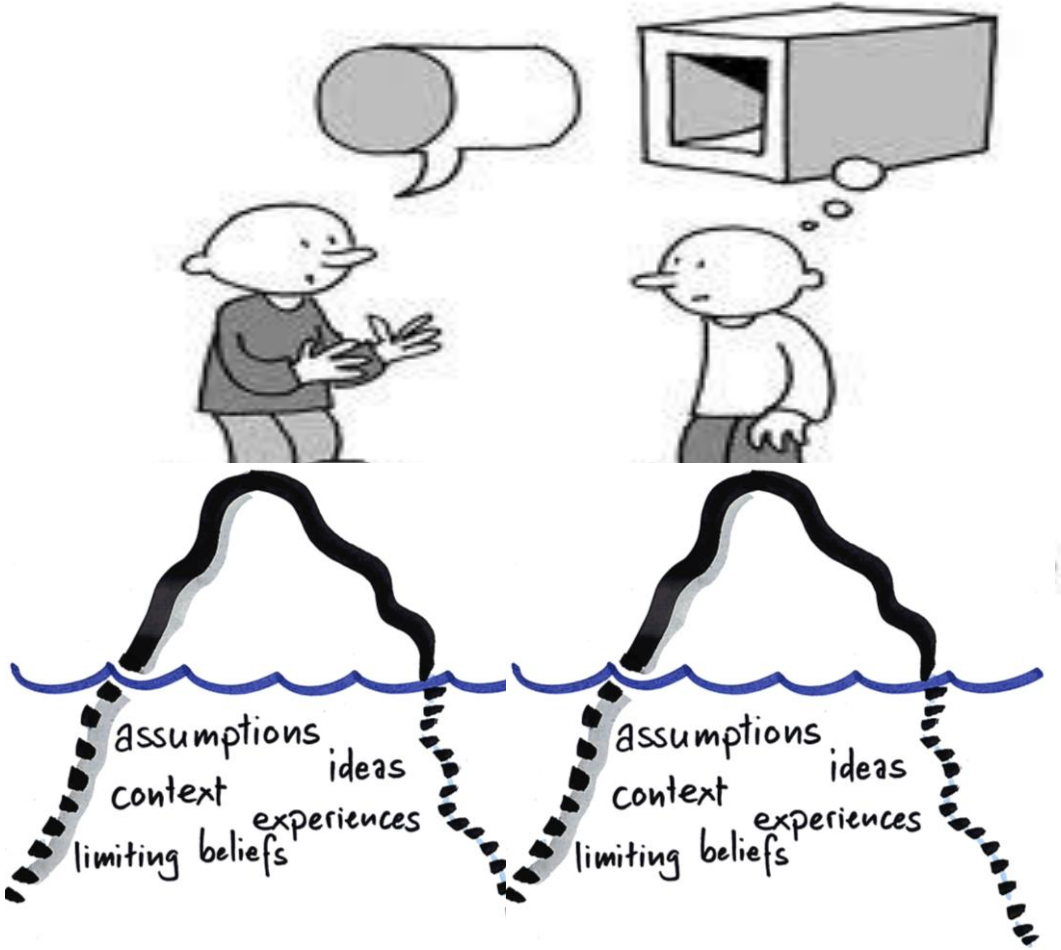


Starting point of the action

- First version of an ecological model using stacked species distribution models was developed
  - Low forecasting quality
  - No inclusion of hydromorphological pressures due to lack of data
  - No adoption of the tool by Flanders Environment Agency in their planning practice
  - The model did not communicate with other water quality models used by Flanders Environment Agency

Decision support as learning tools

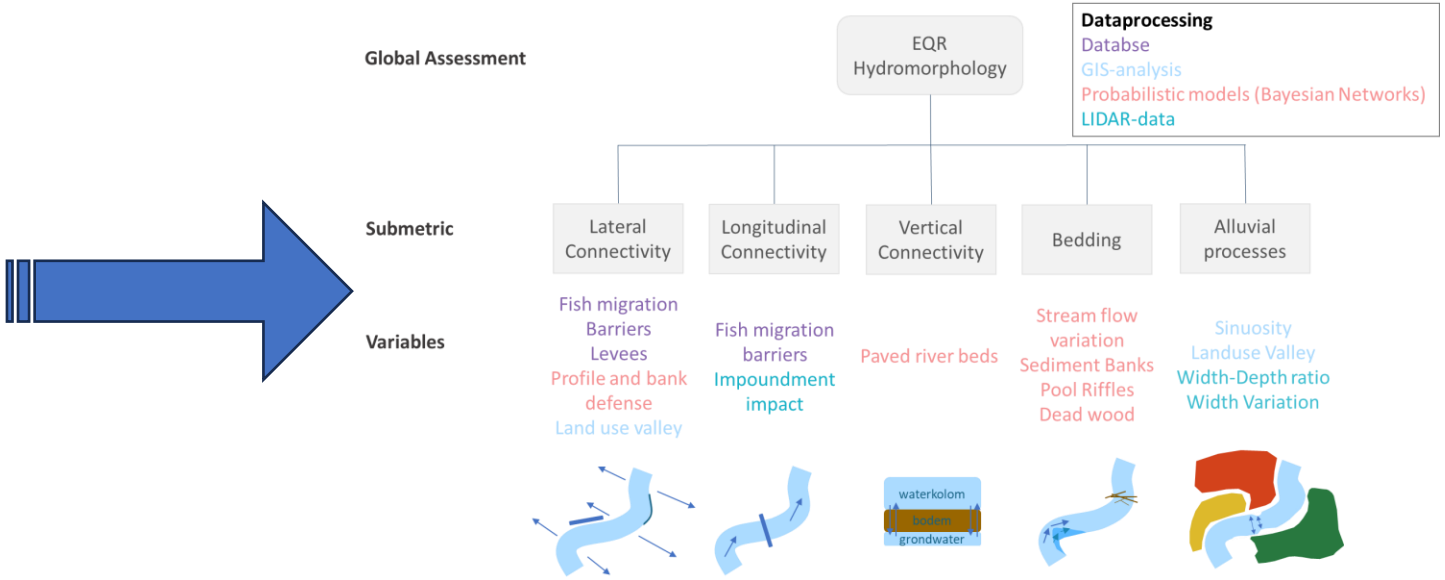
- Good model quality
- Model should align with
  management questions
- Mechanistic understanding
- Model transparency
  (uncertainty; assumptions)



Multiple innovations were realised

- Develop a new input layer with remote sensing data related to hydromorphology
- Adopt a hybrid modeling approach to improve model calibration and include biotic interactions
  - Include expert knowledge, data-driven methods and ecological theory into the modeling framework
- Evaluate the possible role of the model within the planning cycle to ensure more use of the tool
  - Further develop the explanatory mode
- Further improve the forecasting capabilities
  - Integrating with water quality scenarios from PEGASE water quality model
  - Transform the river network into a mathematical graph to improve migration modeling in the species distribution modeling

Challenge 1: a regional hydromorphology map



Global Assessment

EQR Hydromorphology

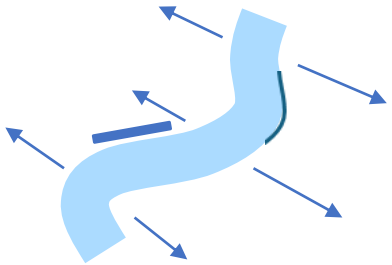
Dataprocessing
Databse
GIS-analysis
Probabilistic models (Bayesian Networks)
LIDAR-data

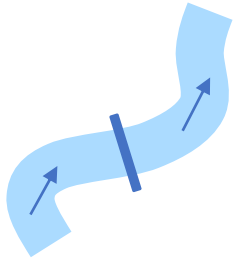
Submetric

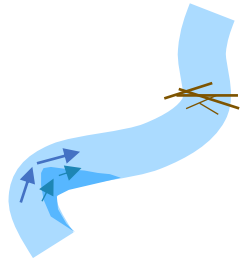
Lateral Connectivity	Longitudinal Connectivity	Vertical Connectivity	Bedding	Alluvial processes

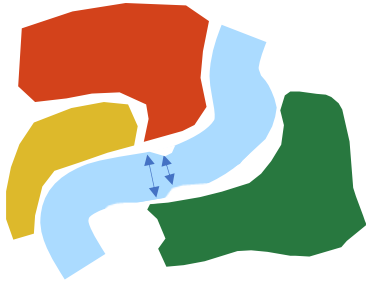
Variables

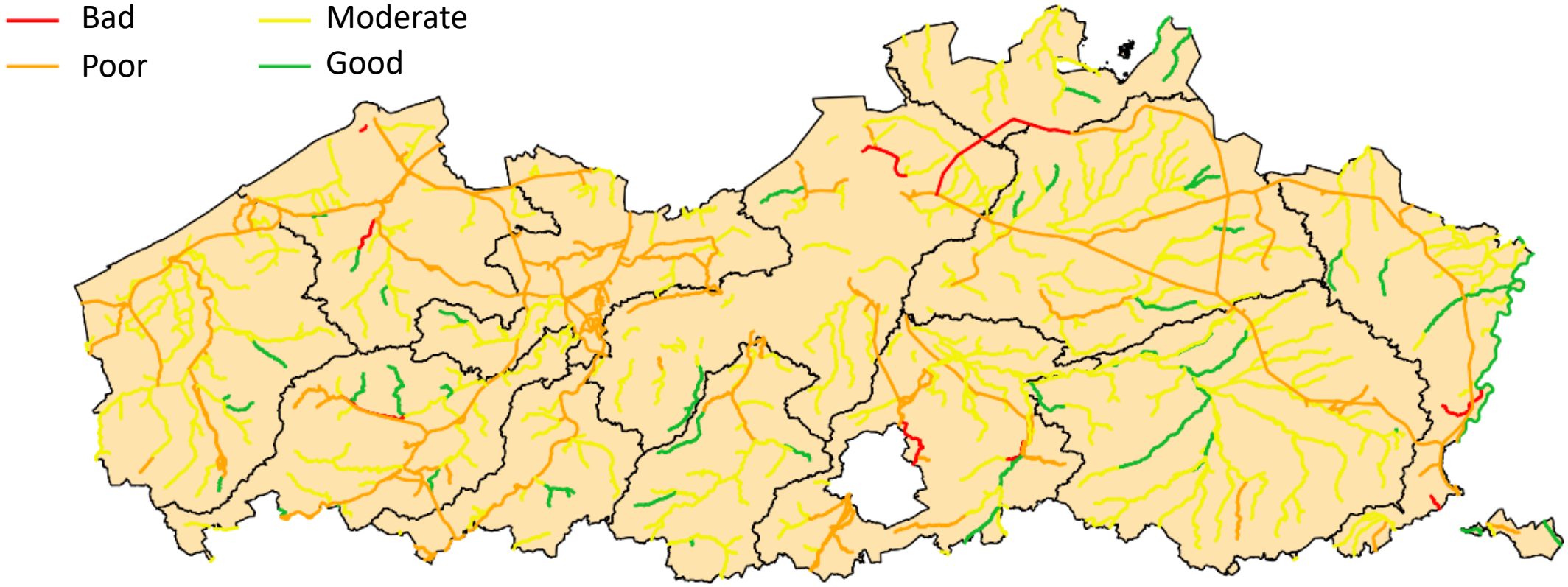
Lateral Connectivity	Longitudinal Connectivity	Vertical Connectivity	Bedding	Alluvial processes
Fish migration Barriers Levees Profile and bank defense Land use valley	Fish migration barriers Impoundment impact	Paved river beds	Stream flow variation Sediment Banks Pool Riffles Dead wood	Sinuosity Landuse Valley Width-Depth ratio Width Variation











Results regionwide hydromorphological map: estimated hydromorphological status

- Preliminary data for RBMP 4 (verification ongoing)
- 90 % coverage of region (vs. 10% coverage field monitoring)
- Average accuracy 70%

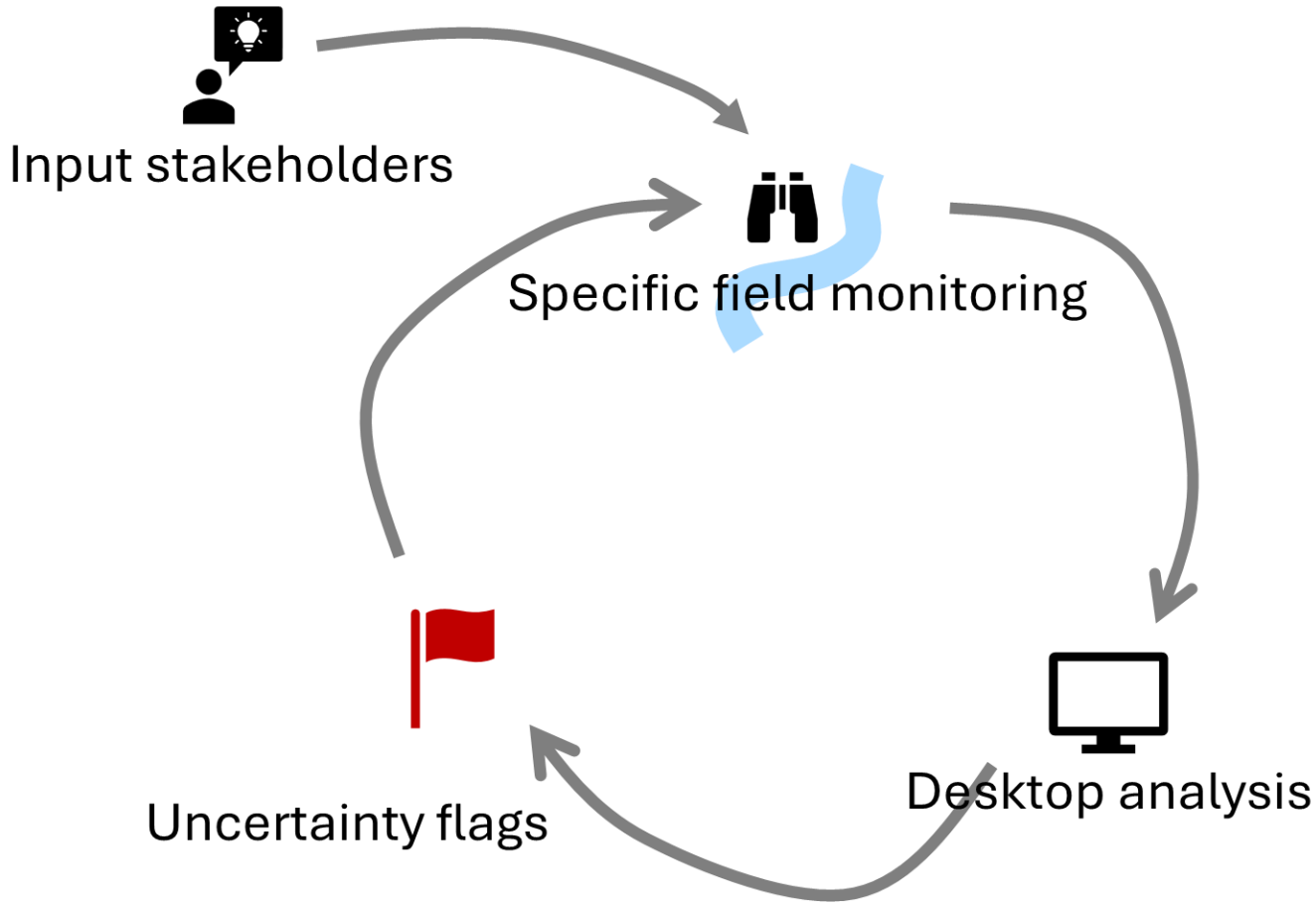
What input can this data provide for RBMP?

- Pressure-Impact analysis (RBMP3)
- Ex ante scenario analysis to assess PoM – together with other water quality models (RBMP3)
- Disproportionality analysis (RBMP3)
- Assessment of hydromorphological state (RBMP4)
- Evaluation of ‘good ecological potential’ for HMWB (RBMP4)
- Calculate hydromorphological gap (RBMP4)

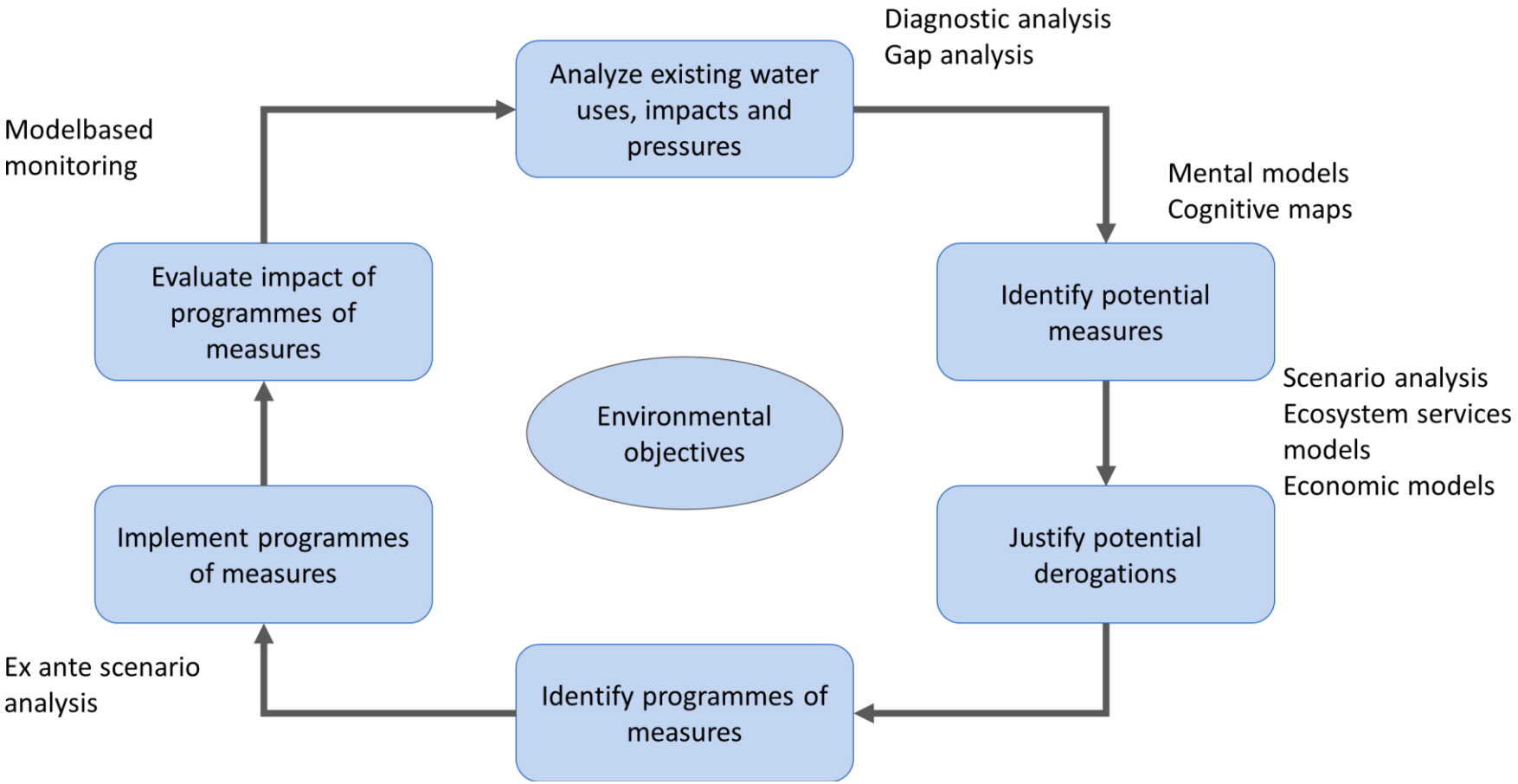
Next step for the hydromorphological desktop application

Marry ‘risk based assessment’ from desktop analysis with in situ observations to increase use of the map by stakeholders

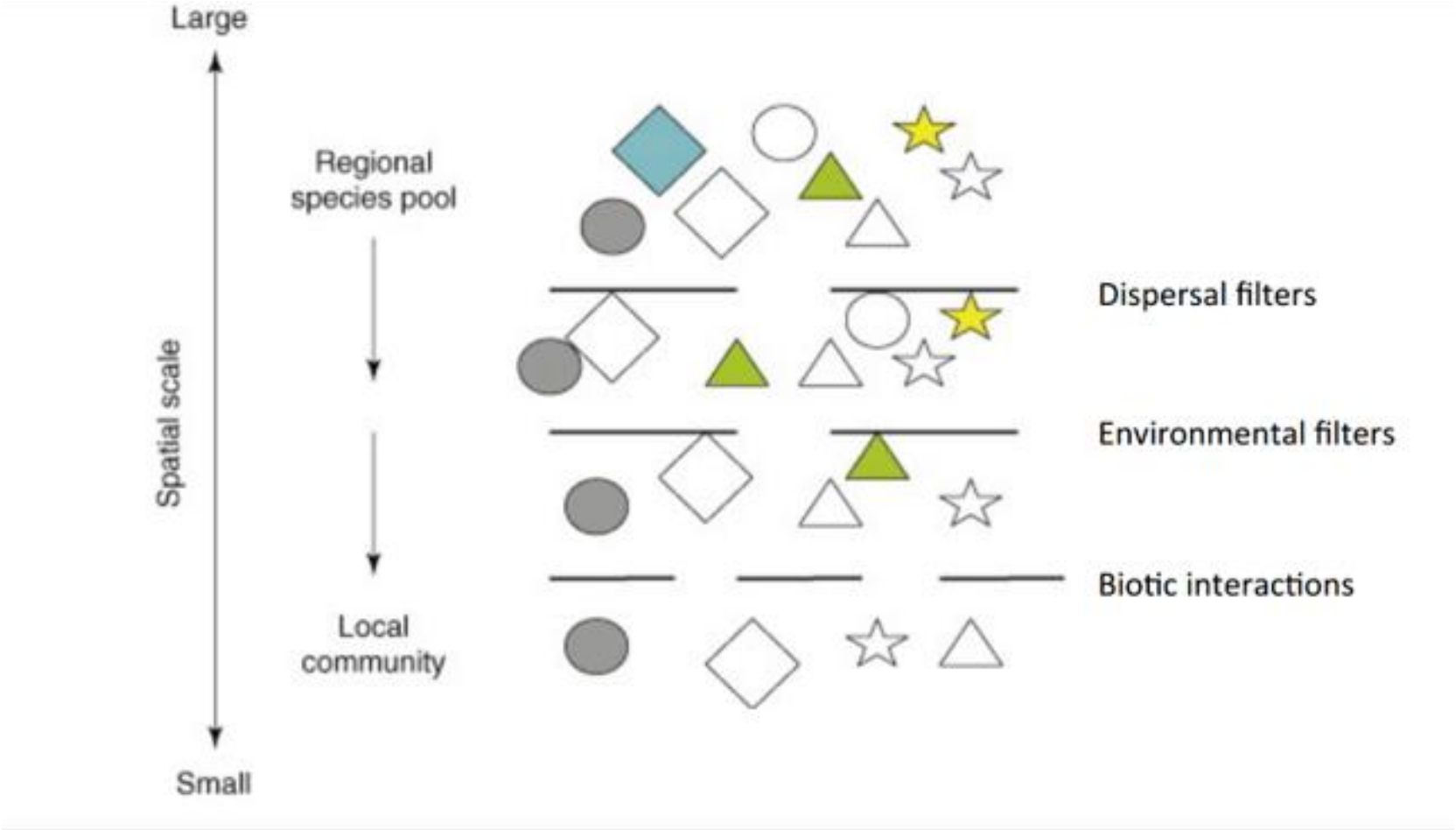
Integrate data in products for RBMP4 and tools to support the planning of hydromorphological actions



Challenge 2: building a fit for purpose ecological model using hybrid modeling



Hybrid modeling: datadriven calibration in a framework based on ecological theory



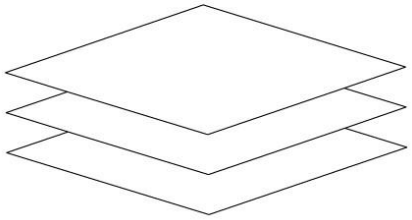
Diagnostic application of the ecological model helps identify the key drivers to adress

Biological data

Missing taxa

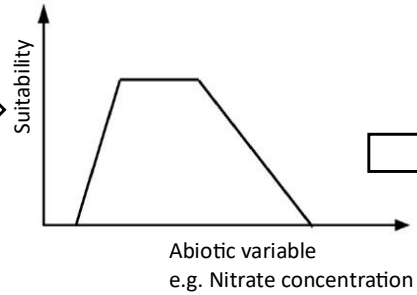
Comparison

Description of reference condition: taxa lists, ecological groups



Abiotic data

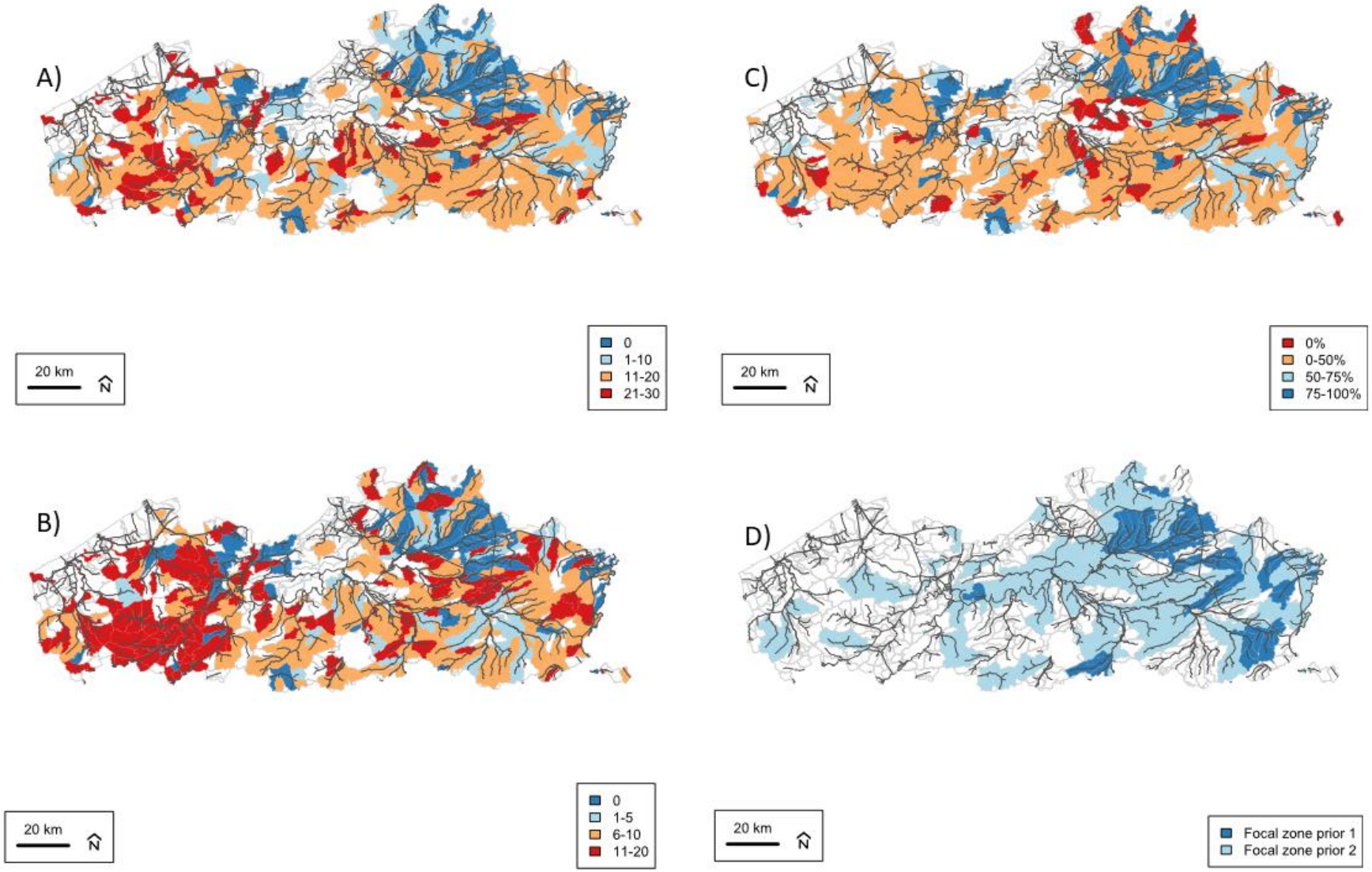
HSI Models



Need for management

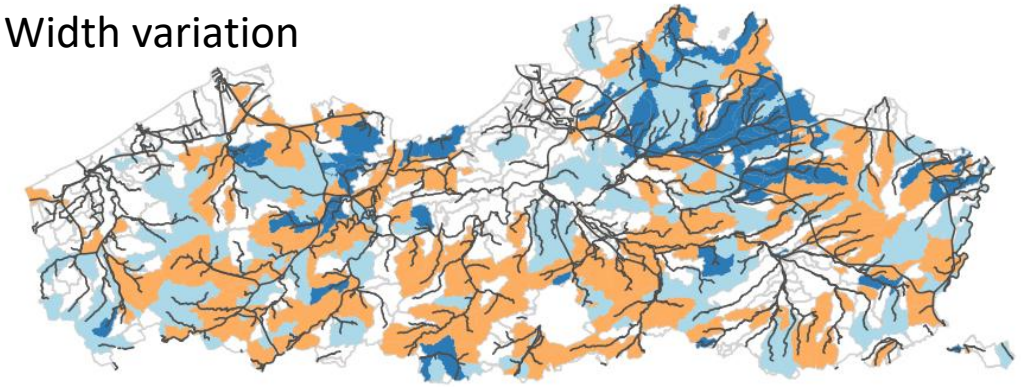
e.g.:
Nitrate: high priority
Bank structure: moderate priority
…

Results diagnostic application (RBMP3)

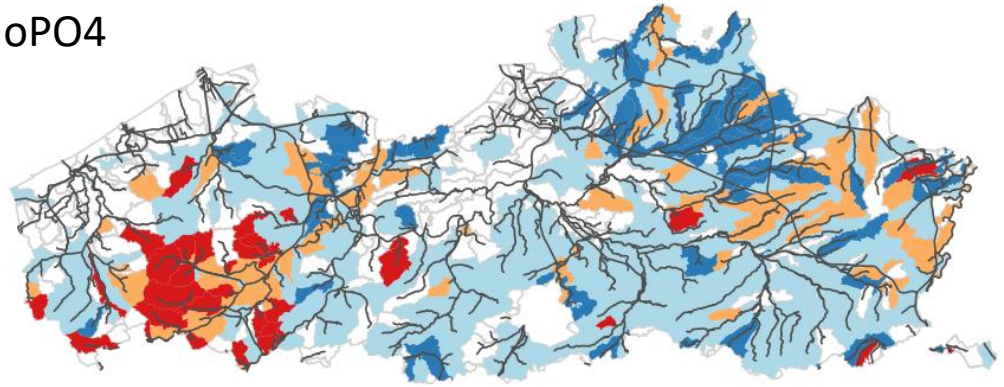


Results diagnostic application (RBMP3)

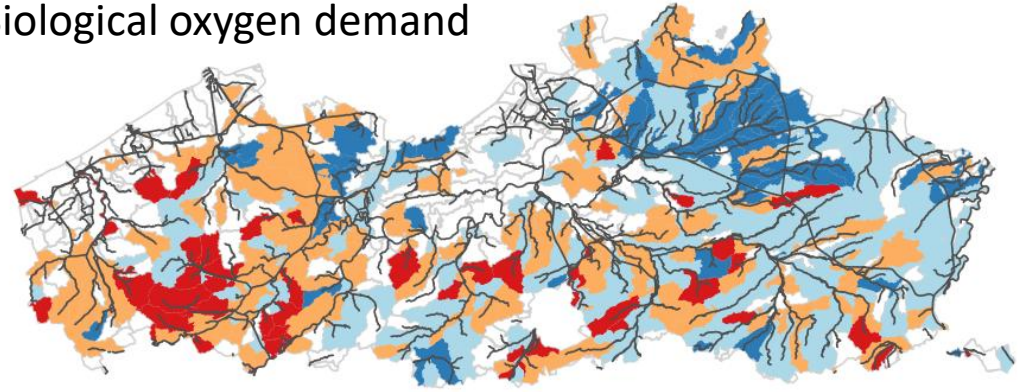
Width variation

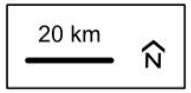


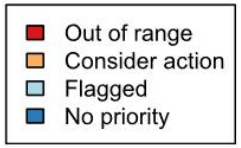
oPO4



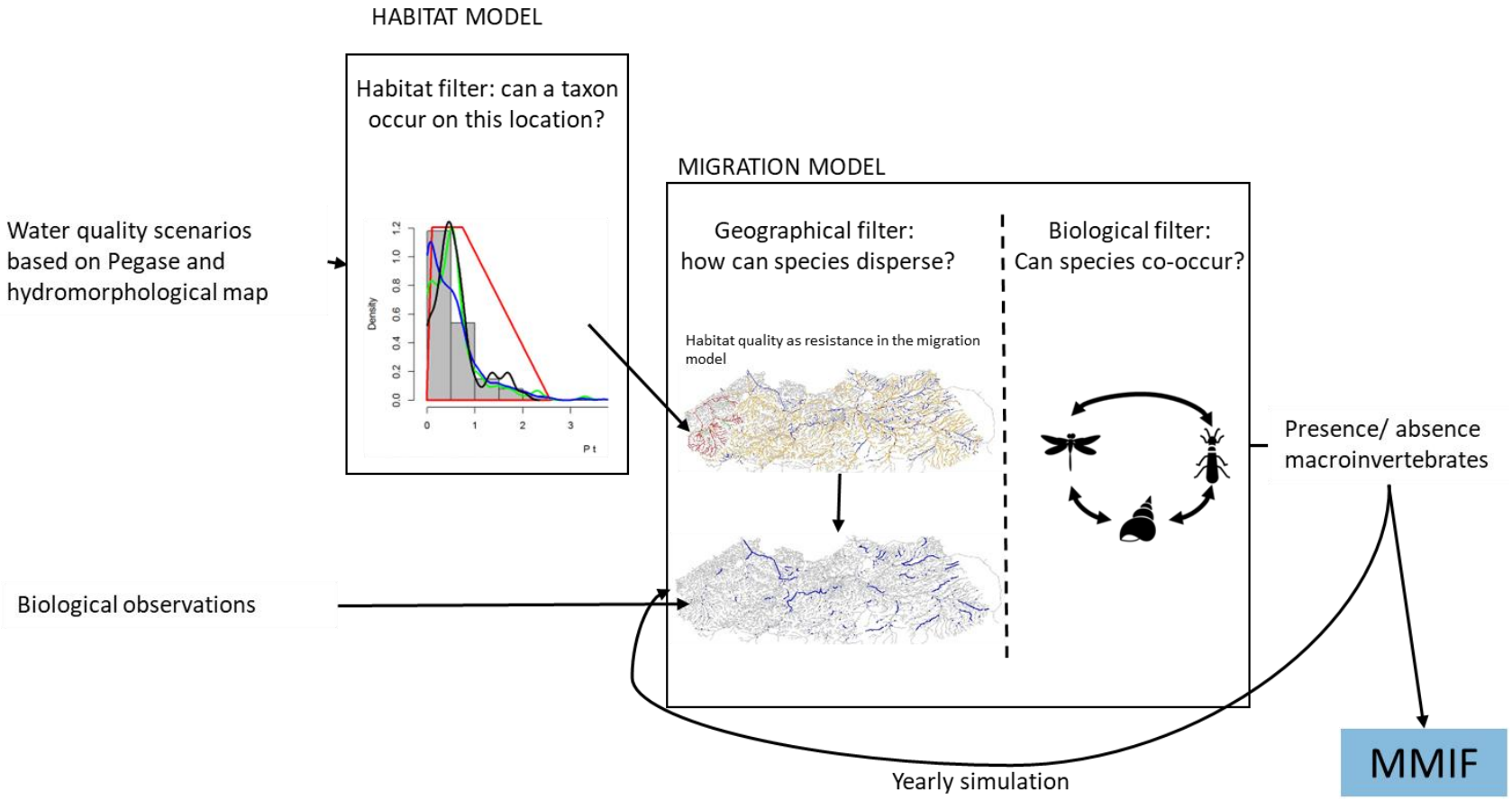
Biological oxygen demand



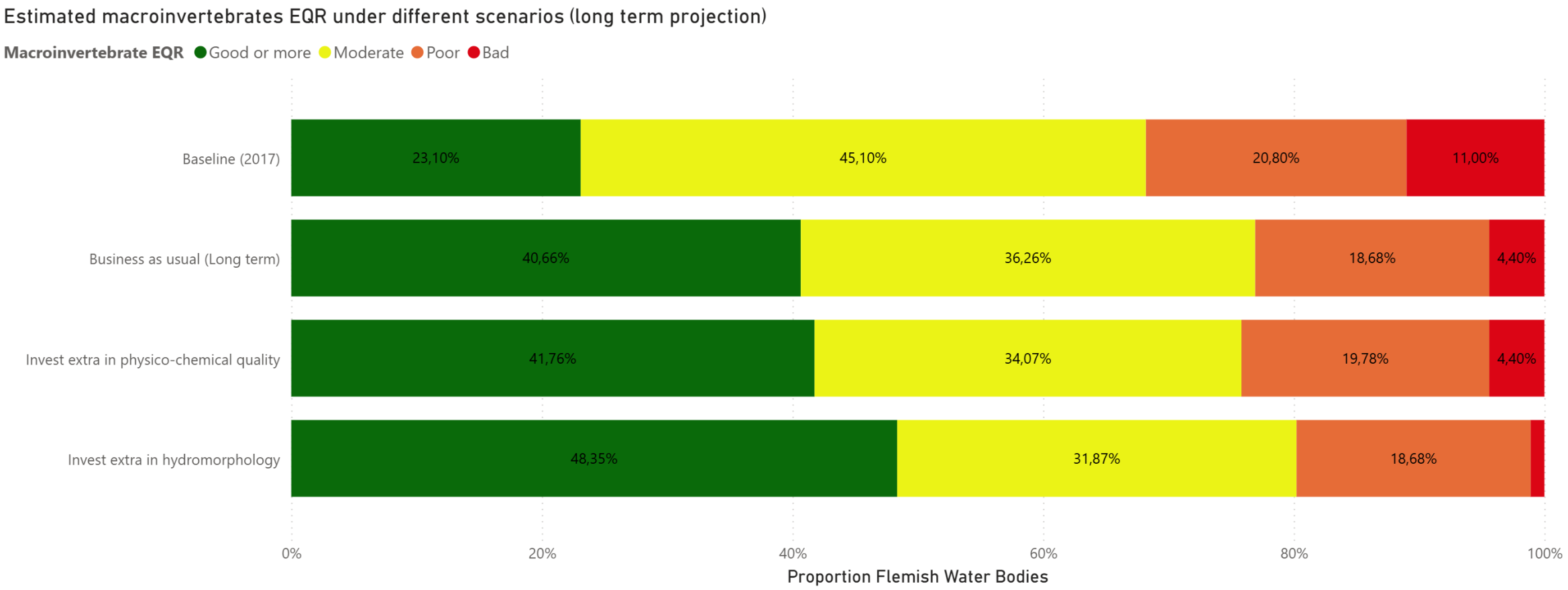




Predictive application of the ecological model helps evaluate scenarios and how much a key driver needs be adressed



Ex ante scenario analysis



Next steps for the ecological model

- Improve versioning systems in model results to create referentiable data
- Integrate model results in easy to use applications (eg Power BI reports) to increase accessibility and adoption by stakeholders
- Adapt to changing environment:
  - New pollution markers
  - Change in resolution and form of input data to which the model was developed
- Extend to other biological groups (Fish, Macrophytes?)

Innovation canvas: introduction

Case study context:

What is the water management challenge?
Who is affected by this challenge?
What is the current approach to managing it?

Design:

What would a digital solution look like in our context?
Who needs to be involved in designing it?
How can we ensure it fits local needs?

Hurdles:

What are the main barriers to adopting digital tools in this case?
Are there technical, financial, cultural, or organizational challenges?

Desired future state:

What would success look like in this case?
What ecological, operation or societal outcomes are we aiming for?
How would things improve for stakeholders?

Implementation:

What resources, skills, or partnerships are needed?
What are the first steps to test or pilot the solution

Enablers and good practices:

What could help overcome these hurdles?
Are there good practices or lessons from other projects we can apply?

Exploration:

What information or data do we need to understand the problem better?
Are there existing tools or practices we can build on?

Integration:

How will the tool be used in daily practice or planning?
What needs to happen for it to be sustained or scaled?

Success indicators:

How will we know the digital innovation is working?
What metrics, feedback, or observations will show progress?

Case study context:
How much does hydromorphological restoration contribute to restoring the good biological status?
What amount of hydromorphological restoration is neederd?
What is the local hydromorpholocial state on this river reach?

Desired future state:
A region wide map of hydromorphological data

Exploration:
LiDAR data and DEM studies were available, levees were already being mapped through this data
Databases on migration barriers and hydraulic structures were available, but scattered

Design:

Does it need to be the exact score, or is a risk assessment enough? For variables where we don't have data we could asses the risk for hydromorpholigcal deterioration through probabliistic modeling

Implementation:

What other external stakeholders have data that we can use? (provinces, municipalities)

Integration:
Is a map enough, or do people want to explore management options?
First and foremost : a first estimate map, rough and dirty through a quick innovation pilot, but regionwide.
After first succesful adoptions and applications we willl refine and add further modalities.

Hurdles:

Going from in situ measurements to risk based estimates and uncertain results
How to keep the data up to date
How to track changes towards the good ecological status
Valorize local river knowledge that cannot be mapped through computer

Enablers and good practices:

Hybrid monitoring strategy, with a lower amount of fieldwork, but a dedicated focus.
Involve river managers in validation and in constructing the knowledge base for the probbalistic models

Success indicators:

Stakeholders use the map and have an acceptance for the data provided.

Example cases

- **Real-Time Water Quality Monitoring in River Basins**
  - Industrial pollution affecting ecosystems
  - Goal: deploy sensors and ML to detect and predict pollution events
- **Catchment-Scale Water Resource Planning**
  - **Challenge**: Balancing agricultural, industrial, and ecological water needs.
  - **Digital Tools**: Digital twins of catchments, scenario modeling, stakeholder dashboards.
- **Wetland Restoration and Monitoring**
  - **Challenge**: Loss of biodiversity and ecosystem services.
  - **Digital Tools**: Remote sensing, digital twin of ecosystems, ML for habitat analysis.
- **Agricultural Water Use Optimization with IoT Sensors**
  - **Challenge:** Rural area with water scarcity
  - **Digital tools:** use soil moisture sensors and AI to optimize irrigation
- **Near real time forecasting of Harmful Algae Blooms in recreational and swimming waters**
  - **Challenge**: have early warning system for recreational users
  - **Digital tools**: satellite based remote sensing, IOT sensors, …
- **Your case …**

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